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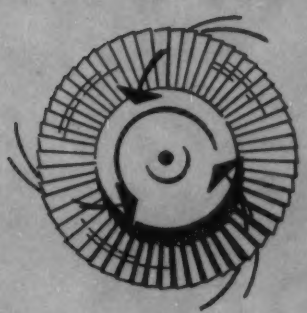
Petroleum Refiner

AUGUST
1957

Special Report on Turbine Drives



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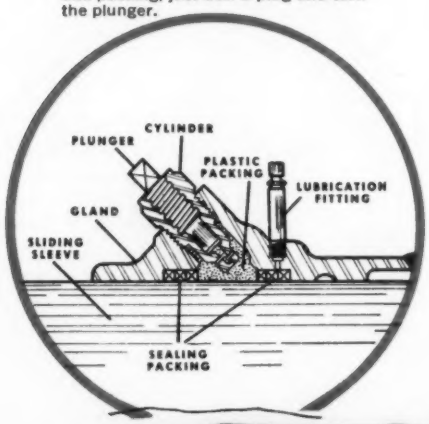

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Volume 36, No. 8 August, 1957

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Petroleum Refiner

REFINING • PETROCHEMICALS • NATURAL GASOLINE

A Quick Look at This Issue

These handy digests permit checking the articles you want to read first. ☑

☐ **Turbine Special Report** . . . Here's a design series that points out some of the unusual aspects of selecting turbines. The engineer who designs a process system is often confronted with the economics of selecting a drive for his particular application. This report shows him how to make the most economical selection. It will also show him some of the more prominent refining and petrochemical processes and how a turbine can be used in these processes. Europe is well ahead of the U. S. in utilization of the free-piston gasifier, driving turbines. The report includes a special article, direct from England, summarizing the continental designs and how they could work for you. **Pages 109-137.**

☐ **Which To Use: Turbine or Motor Drives? . . .** When selecting large-horsepower, high-speed prime movers, a designer must consider every factor. Here's a method that allows you to tabulate the factors and select the most economical driver for your application. For complete details, turn to **Page 110.**

☐ **How Turbines Can Work In Your Process . . .** The versatility of a self-contained gas turbine as a prime mover permits its use to supply a wide variety of process requirements for lower cost plant operations. The trend in steam turbines is to the use of higher steam conditions, more feedwater heating and the use of mechanical drive turbines to reduce overall operating costs. For complete details, turn to **Page 116.**

☐ **Europe Likes Free-Piston Turbine Drives . . .** Here's a roundup of European free-piston gasifiers for turbine drives. It tells you how they work and advantages for application to your plant's operations. Turn to **Page 127.**

☐ **What's Required For Turbine Foundation Design . . .** Here's a review of the principles required for turbine foundation design—with a treatment for design on unstable soil. It gives all of the load considerations that should be made, plus a typical foundation detail. Turn to **Page 133.**

Please Turn Page ➡

A Quick Look at This Issue . . .

☐ **Desiccant Performance at Gabe Plant . . .** With five years of operation behind them, Tennessee Gas Transmission engineers report their experience with two desiccants. Comparison of pressure drop, dry gas capacity and volume capacity are made. Use these data when considering new dehydrating agents for your natural gas. Turn to **Page 138.**

☐ **Watch these OXO Alcohols . . .** Since their introduction in 1948, higher oxo alcohols have shown rapid growth. New uses, coupled with ample production, point to a continuing growth. Study this method of converting olefin intermediates into marketable higher alcohols. Turn to **Page 141.**

☐ **Estimate Tower and Drum Surfaces . . .** This handy chart was constructed for cylindrical vessels having 2:1 elliptical heads. It will help you with estimates for insulation requirements, safety valve calculations, and other purposes because you can read-off quickly the total surface area of a tower or a drum. Turn to **Page 146.**

☐ **Calculate Fluidization Rates . . .** Here is a review of the effects of variables which lead to particulate and aggregative fluidization. You will also find a generalized chart for computing incipient fluidization rates and the velocity-bed density relationship for the particulate mode—plus a suggested mechanism of fluidization which enables use of the particulate correlation to calculate the fluidization characteristics of the aggregative mode. This is a must. Clip for your design work book. Turn to **Page 147.**

☐ **Need Help With Gas Chromatography? . . .** If you are using or considering chromatographic methods, be sure to try the columns and partition liquids suggested in the informative report starting on **Page 157.**

☐ **Effect of Pressure on Thermal Conductivity of Liquids . . .** When you get to high pressures you must take into account the pressure effects. Here are the reasons why. In this timely report you will also find a generalized correlation that will enable you to get values of thermal conductivity for almost any liquid you may use. Here's another one for the notebook. Clip this one from **Page 162.**

☐ **Automation Today (Part 11) . . .** This is a continuation of the interesting series on automatic control. The author has finished a discussion of the various components of the control loop and will now consider computer simulation. Before having the computer to take over this task, review the important factors starting on **Page 166.**

☐ **Will Liquefaction of Natural Gas Pay? . . .** This study shows all the costs for liquefying natural gas at cheap sources, plus shipping costs to New York and the North Sea. On paper, the payouts look very attractive. For the complete story, turn to **Page 169.**

☐ **Disaster Planning Pays Off . . .** Refineries caught in the path of Hurricane Audrey have reported relatively small damage. Reasons: Early disaster planning—sticking to a predetermined plan—proper timing of shutdown operations. How these three factors were combined into a successful disaster plan operation is explained in this informative case history of a refinery put to test under hurricane conditions. You will also find a highly interesting report on the personal sacrifice oil people made to relieve suffering in the disaster area. Turn to **Page 207.**

☐ **Why Have a Safety Program? (Part 8) . . .** Here is the first of three articles outlining the fundamentals of safety and fire protection. As an introduction, one of the nation's top safety authorities explains causes of accidents, then gives the reasons why every refinery needs an effective safety and fire protection program. For some effective answers to management's questions about safety, turn to **Page 210.**

☐ **What Makes a Good Supervisor? . . .** Through experience and counsel, refinery management has devised a definite standard to determine whether an employe is made of supervisory timber. Here is an interesting summary of these time-proven selection factors. In fact, you will find a list of 28 qualities a supervisor should have. Be sure to check this list, it is filled to the brim with good ideas. Turn to **Page 216.**

☐ **Make Your Training Program Succeed! (Part 2) . . .** The purpose of any training effort is to create a desired attitude and skill among employes. In this analysis of a 50-company survey, you will find all the elements needed to reach your training goals. Check to see how these suggestions fit in with your present program. Turn to **Page 224.**

☐ **Wonder What's Going On? . . .** You won't have to wonder once you read "What's Happening in the Industry," PETROLEUM REFINER's accurate presentation of those items that made the news last month. The clear and precise manner in which the events are reported is just what's needed by busy industry men who don't have time to wade through unimportant details to get to the meat of the subject. And when you come to the end of this section, you'll find **Changing Times,** a list of rapid-fire news flashes that provides the final touch for keeping you informed on **What's Happening in the Industry.** Turn to **Page 230.**

☐ **New Equipment Is News . . .** It is for this reason that PETROLEUM REFINER devotes an entire section to the new products and literature presented by the various manufacturers to the men of the refining-petrochemical-natural gasoline industry. The equipment items presented in **What's New in Equipment and Manufacturers Literature** have been carefully screened by our new equipment editor so that you may keep pace with the new products in this constantly changing industry. See for yourself . . . turn to **Page 268.**

Petroleum Refiner

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Petroleum Refiner is indexed by Industrial Arts Index, Chemical Abstracts and by Engineering Index, Inc. Microfilm copies available through University Microfilms, Ann Arbor, Michigan.

September's Big Value

NEW DEVELOPMENTS in petroleum refining carry top billing in the September issue of PETROLEUM REFINER. This is your chance to up date yourself on new processes, new techniques, and recent operating data.

September's Process Development Issue will cover the processing method which is doing the lion share of furnishing octanes—reforming. There also will be coverage of that new addition to the family of upgrading processes—pentane isomerization. And many others.

For a bonus, a special section will be devoted to process design. The backbone of this section is a primer on design methods containing such topics as: how to draw flow sheets, what to include in a cost evaluation, how to estimate plant costs, and others.

That's not all. Presented will be a group of articles on scale-up, the principle necessary to change sizes of processing units without violating specific processing conditions.

Lots of value in that September issue, a companion volume to PR's authoritative Process Handbook!

Here's a Switch:

THE BEST LAID PLANS of mice and men—and that, believe it or not, includes editors—oft go awry. "What Engineer-Contractors Do" an article originally scheduled for this issue had to be set back a month because of the excellent and timely "Turbine Special Report" which starts on page 109. Many of the unusual considerations necessary in turbine drive selection are listed in this splendid Special Report which we recommend as heartily as we did—and do—the Engineer-Contractor article now fixed for September publication.

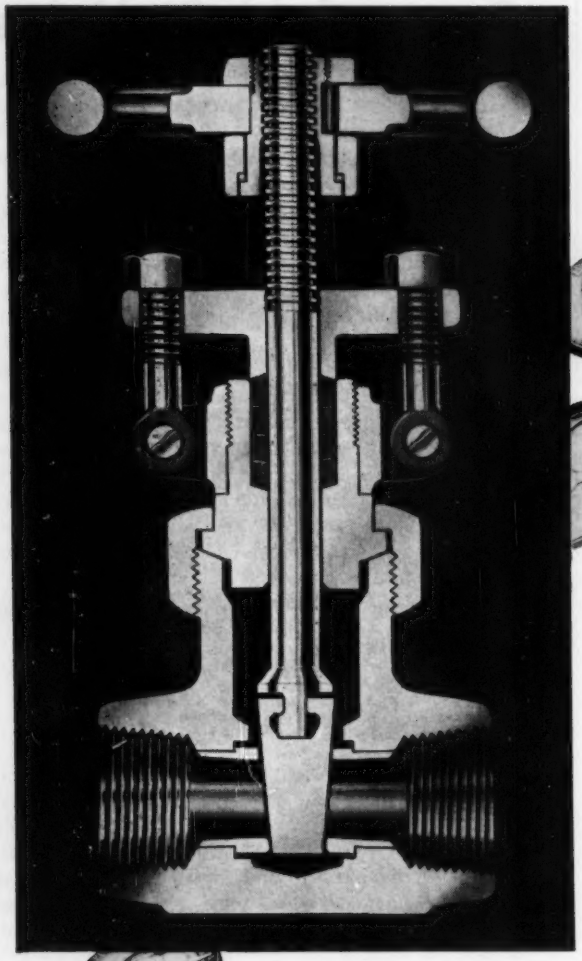
Advice for the Author

HERE'S SOMETHING you might remember if you run across an engineer who is working on that book which many of them plan to write "one of these days."

Gulf Publishing Company, which publishes three specialized magazines for the petroleum industry, also publishes books of a technical nature.

So we are interested at all times in reviewing technical manuscripts looking toward book publication. Such material may or need not first appear in the columns of one of our magazines, PETROLEUM REFINER (refining, petrochemicals, natural gasoline), *World Oil* (exploration, drilling, producing) and *Pipe Line Industry* (construction, operations, maintenance).

Keep this in mind and if the opportunity arises suggest to authors, present or prospective, that they contact us about those books they have in the mill.



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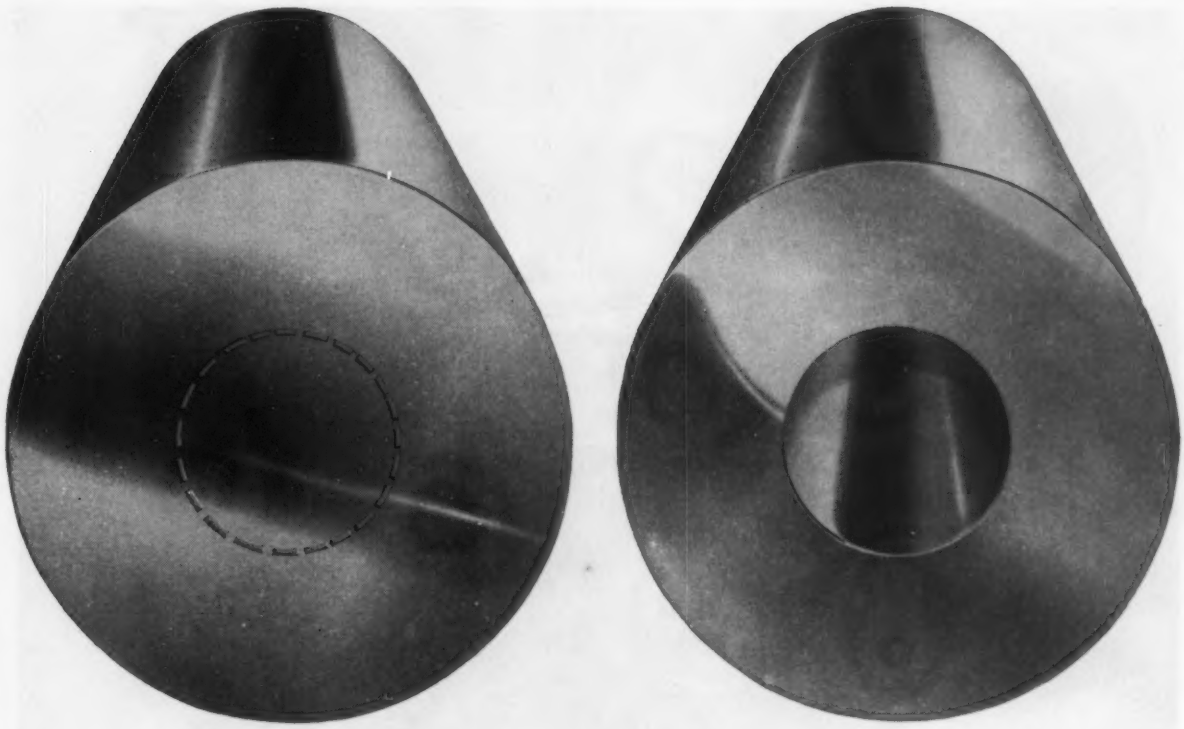

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JACK B. RINCKHOFF (right), Chief Engineer, Sulphuric Acid & Phosphates Dept., Chemical Construction Corp., N. Y. City. Left, Michael De Piano, New York Cooper Alloy Representative.

RINCKHOFF OF CHEMICAL CONSTRUCTION

answers 3 questions on Cooper Alloy Valves

Q. Mr. Rinckhoff, in specifying equipment for the H_2SO_4 plants that Chemico constructs around the world, what Cooper Alloy valve models do you buy most of?

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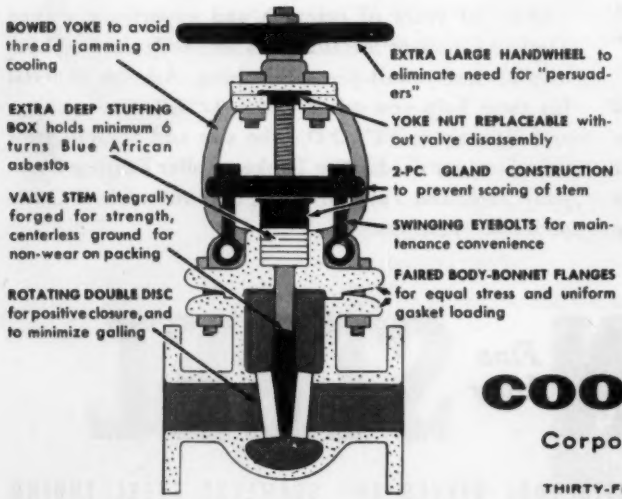
A. Availability. Your chain of distributors across the country and in remote parts of the world is of great importance to us. In foreign construction we have often specified Cooper Alloy because of this all-important availability.

Q. What about design and quality?

A. Vital. Valve design determines performance, and our specifications are rigid. As a construction company, we can't afford to jeopardize our reputation by installing questionable equipment. Cooper Alloy valves have passed our tough specs, and have my approval for all severe construction applications.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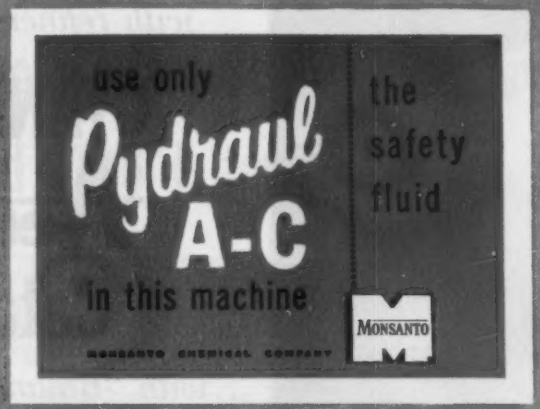

This seal on an air-compressor spells SAFETY from lubricant-caused fires and explosions

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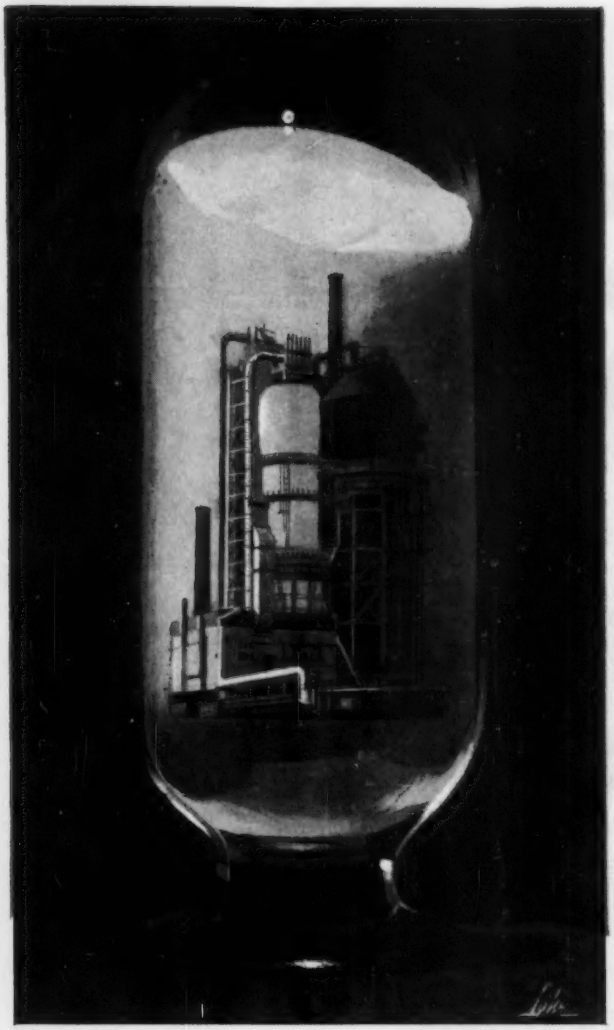

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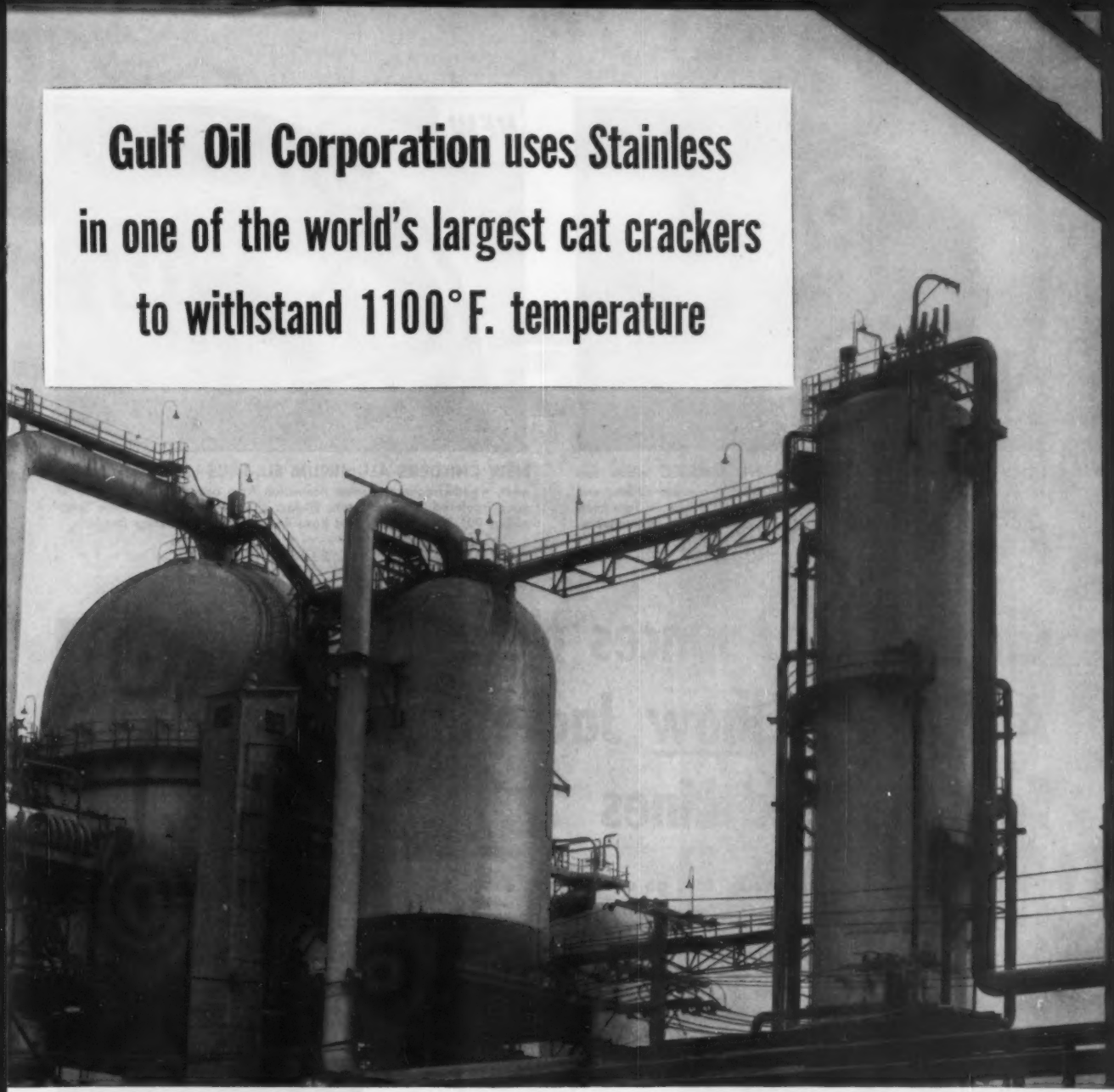
Gulf Oil Corporation uses Stainless in one of the world's largest cat crackers to withstand 1100°F. temperature



One of the largest catalytic crackers in the world, at Gulf Oil Corporation's Philadelphia refinery. Regenerator at left produces about 64,000 barrels per day.

IN ITS PHILADELPHIA REFINERY, Gulf operates one of the world's largest catalytic cracking units. It produces high octane gasoline, heating oils, fuel gas, gas oil, propane-propylene and butane-butylene. Capacity is about 64,000 barrels per day. 9 million pounds of catalyst circulate each hour, and the unit consumes nearly 400,000 pounds of steam per hour.

The top of the spherical regenerator is shingled with 14-gage Stainless Steel strip. Temperature reaches about 1100° F. in the burning atmosphere, and the Stainless Steel shingles resist erosion caused by the pressure circulation of the catalyst, which has the consistency of talcum powder. Carbon steel shingles would deteriorate and fail rapidly. Bottom section and cone of the fractionating tower (right) are lined with Stainless Steel to withstand corrosion at high (700° F.) temperature.

Stainless Steel gives you the most for your money when it is designed *into* equipment, right from the start. So think of Stainless Steel when you design. Think of *USS* Stainless when you buy.

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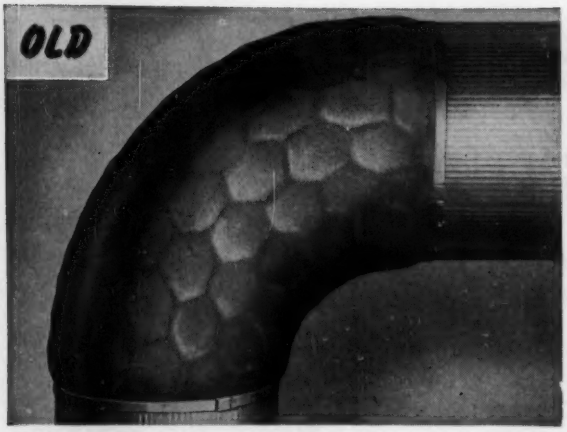
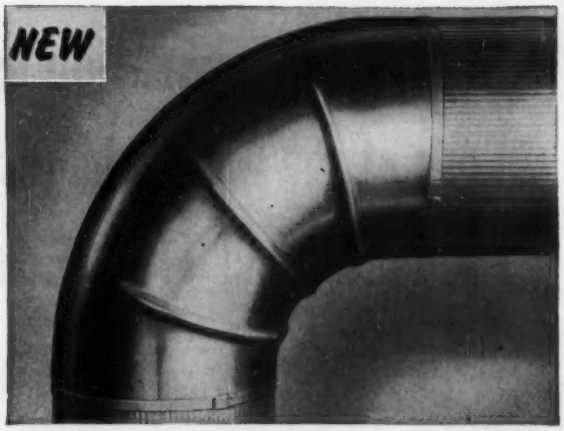
SPECIAL SECTIONS

UNITED STATES STEEL



UGLY, COSTLY CHICKEN WIRE AND MASTIC elbow coverings like this are now obsolete. New Childers Aluminum Ell-Jacs end the need for slow, costly hand-made "patches". Childers Ell-Jacs keep their new look, never need expensive periodic painting or maintenance.



NEW CHILDERS ALUMINUM ELL-JACS now make possible neat, weather-tight aluminum protection from one end to the other of your insulated lines. Childers Ell-Jacs are precision formed for long-radius 90° and 45° ells and have factory-applied moisture barrier.

Childers Announces New Aluminum Elbow Jacketing For Insulated Lines

Revolutionary new Childers Ell-Jacs go on fast and easy . . . fit perfectly . . . cut installation costs . . . never need painting . . . and, used with Childers Jacketing, give your insulated lines that well-dressed look from end to end.

Now, aluminum elbows are made in a wide range of sizes by America's leading manufacturer of aluminum jacketing. Childers Aluminum Ell-Jacs are available for quick, easy application to protect costly elbow insulation.

Childers Ell-Jacs, together with Childers Jacketing, enable you to install maintenance-free aluminum over every square foot of your valuable insulation. You protect *all* of your insulation investment at lowest cost. You get the bonus of a better looking plant and easier housekeeping. Aluminum *keeps* its new look, needs no expensive periodic painting.

Positive weather-proofing, too, is assured by exclusive Childers Lap-Seal (Patents Pending). Factory-attached moisture barrier prevents harm to the underneath side of the aluminum.

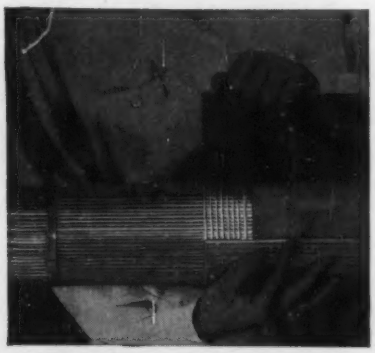
First cost is less for Childers Jacketing than for any other permanent type weatherproofing—even less than some temporary coverings.

You also get greater strength and greater protection because Childers Jacketing is cross-crimped.

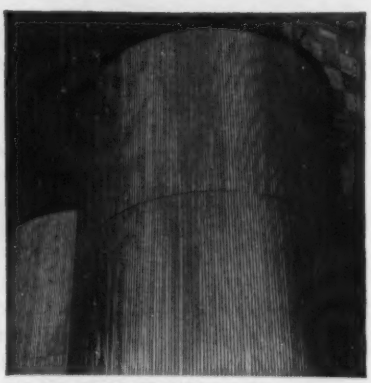
It's easy to install Childers Jacketing. All you need are pliers and screwdriver, plus inexpensive strapping. Two men can do the job. Jacketing can be removed for inspection of the lines, then reapplied without waste.

Why not benefit from Childers world-wide experience when you buy insulation for your lines, towers, vessels, and tanks? More than 2,000 petroleum refining, petro-chemical, and chemical plants will endorse your decision. Childers Engineering Representatives, located in 27 major industrial centers, give professional advice on insulation jacketing.

For a free sample of Childers Aluminum Weather-Proof Jacketing, with engineering data on how to safeguard your insulation, write Childers Manufacturing Company, Dept. PR-38, P. O. Box 7467, Houston 8, Texas. (Adv.)



EXCLUSIVE LAP-SEAL, available at no extra cost, is a series of 8 ribs rolled into the underlapping edge of the jacketing, providing automatic measure of the 2" circumferential lap. Proper lap is assured without waste. Labor is saved. Where desired, a positive weather seal is easily made with Lap-Seal and a mastic.



DEEP CORRUGATED Childers Jacketing in 1¼" and 2½" corrugations is recommended for permanent protection and improved appearance of insulated towers, vessels, tanks. Deep Corrugated Jacketing with factory-attached moisture barrier is another product available only from Childers.

See Childers' ad in Sweet's, Chemical Engineering Catalog and Refinery Catalog.

Recovery is good business

Consolidated's acid recovery process is typical of the services this company performs for Gulf Southwest Industry—it's good business for all concerned. By means of this service, black, corrosive sludge acid is converted from a disposal problem into an asset in the form of fresh, white, 99% sulphuric.

Consolidated is the big name in sulphuric acid for the Southwest. Five strategically located plants supply the petroleum, petrochemical and chemical industries concentrated in this area.

Whether your requirement is for new acid or for disposal and recovery of spent acid, you'll want to get all the data on point of shipment, price and delivery. You'll like doing business with Consolidated.

Stauffer CHEMICALS SINCE 1885

CCI

CONSOLIDATED CHEMICAL INDUSTRIES

DIVISION OF STAUFFER CHEMICAL COMPANY

640 Esperson Building
Houston 2 Texas

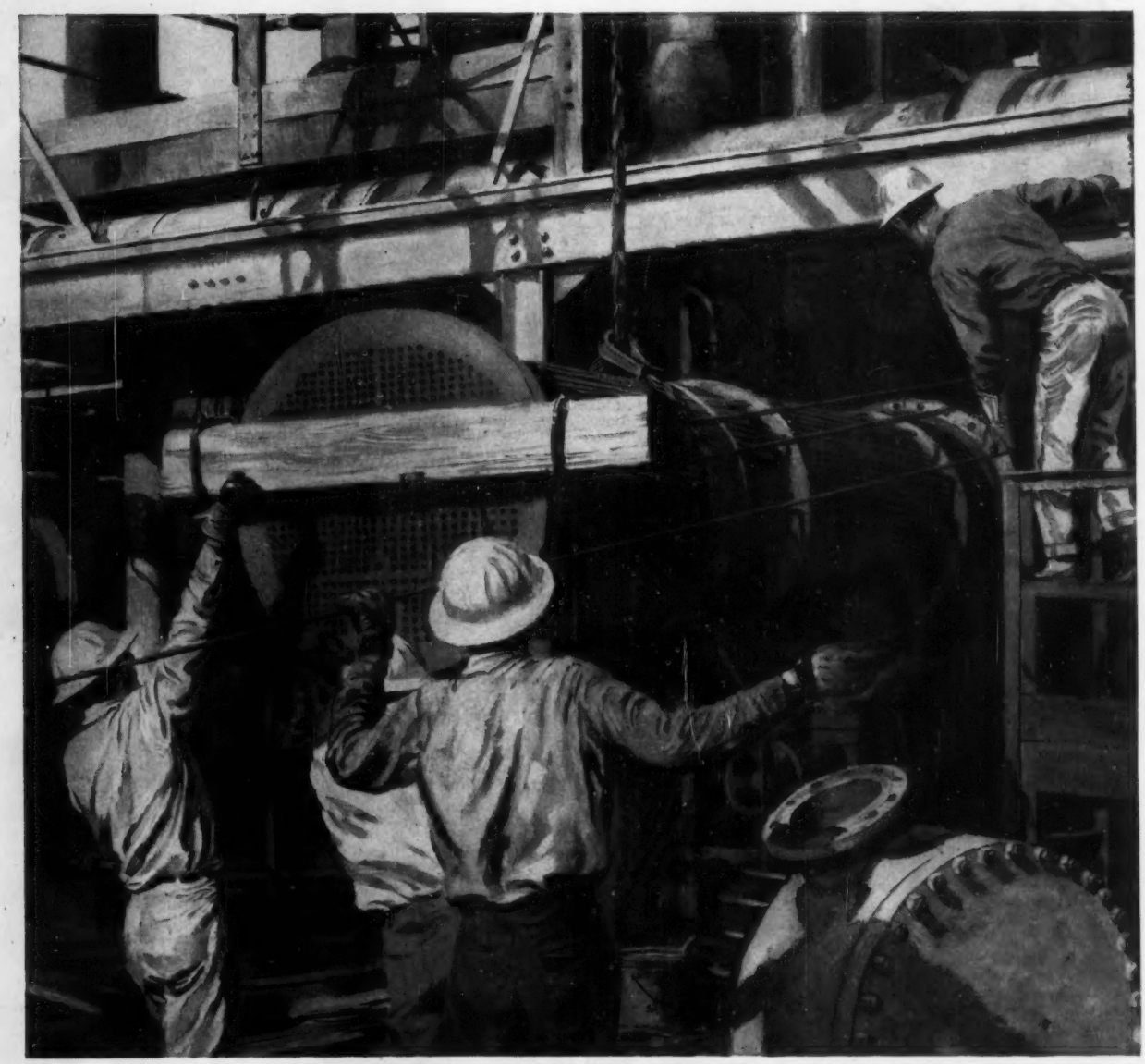
•

380 Madison Avenue
New York 17, N. Y.

RETUBE YOUR BUNDLES WITH

PHELPS DODGE HEAT EXCHANGER AND CONDENSER TUBES

FOR LONG-RUN RELIABILITY!



- Wide range of finest quality copper-base alloys—bi-metal combinations—to fit your application needs.
- Well-stocked, nation-wide warehouses at Houston, Tulsa, Los Angeles and Bayway, N. J.
- Experienced engineering staff at your service to help solve tube corrosion problems.

Specify Phelps Dodge . . . a leading manufacturer of tubes for the fabricators of heat exchangers and condensers!

PHELPS DODGE COPPER PRODUCTS CORPORATION

PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!

For more data on advertised products, use Readers' Service Cards, last page.

Bingham "KOKE-KRUSHER" HOT OIL PUMP

NON-CLOGGING!

PULVERIZES LARGE PIECES OF ENTRAINED COKE IN PUMPAGE

Bingham Type CKM "Double Volute", Two Stage, "KOKE-KRUSHER" for handling hot, coke-laden pumpage at high heads.

- Results in more hours on stream—less down time.
- The pulverizing action on entrained solids reduces clogging of other system equipment.
- Non-pulsating flow eliminates need of auxiliary equipment for control of pressure and/or capacity.
- Eliminates expensive protective devices.
- Smooth pump characteristics eliminate destructive vibration.
- Lower maintenance. Only one moving part.

HANDLES COKE-LADEN HOT OIL IN CRACKING SYSTEMS WITHOUT CLOGGING

The Bingham "Koke-Krusher", the only pump that crushes coke, is a field-proven, centrifugal pump specially designed for the severe services of pumping oil products such as *Residuum, Flash Tower Bottoms, Black Oil Recycle*—in which the oil carries in suspension pieces of hard coke of irregular size and shape.

This revolutionary Bingham pump features a coke crushing mechanism located in the suction chamber immediately in front of the impeller eye. Any piece of solid coke entrained in the pumpage *must* pass through the crusher, where it is instantly pulverized, before entering the impeller.

The resulting pulverized coke particles are small enough to assure free flow through the pump and all system equipment. The Bingham "Koke-Krusher" will make a big difference in your operations. Call your nearest Bingham office for full details. Send for Bulletin 106.

PARTIAL LIST OF MAJOR OIL COMPANIES WITH BINGHAM KOKE-KRUSHER PUMPS IN OPERATION OR ON ORDER

ESSO Standard Oil Company
Gulf Oil Company
Texas Oil Company
Canadian Petrofina, Ltd.
Champlin Refining Company
Shell Oil Company
Sinclair Refining Company
Socony Mobil
Imperial Oil Company, Ltd.
McColl Frontenac Oil Co., Ltd.

Bingham SINCE 1921

DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY

General Offices: **2800 N.W. Front Avenue, Portland 10, Oregon**

Factories: **Portland, Ore. • Vancouver, B. C., Canada**

SALES AND SERVICE OFFICES

BOSTON, MASS.
CHICAGO, ILL.
CLEVELAND, OHIO
DALLAS, TEXAS
DENVER, COLO.
HOUSTON, TEXAS
KANSAS CITY, MO.
LOS ANGELES, CALIF.
NEW ORLEANS, LA.
NEW YORK CITY, N.Y.
PHILADELPHIA, PA.
PITTSBURGH, PA.
SAN FRANCISCO, CALIF.
SEATTLE, WASH.
ST. LOUIS, MO.
ST. PAUL, MINN.
TULSA, OKLA.
TORONTO, ONT., CAN.
VANCOUVER, B. C., CAN.

What *lead does to control corrosion*

in producing and storing Phosphoric Acid

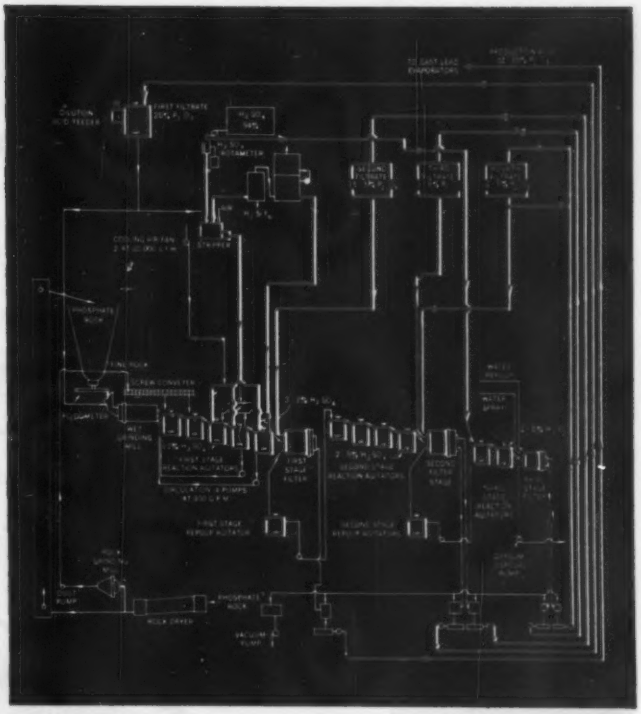
H_2SO_4 and P_2O_5 are a hungry pair.

They eat right into most metals. But *lead* takes the sharp edge off their hunger quickly.

With each of these chemicals, *lead* reacts on contact to form on the surface of the metal an insoluble and impervious film. This film stops further corrosion.

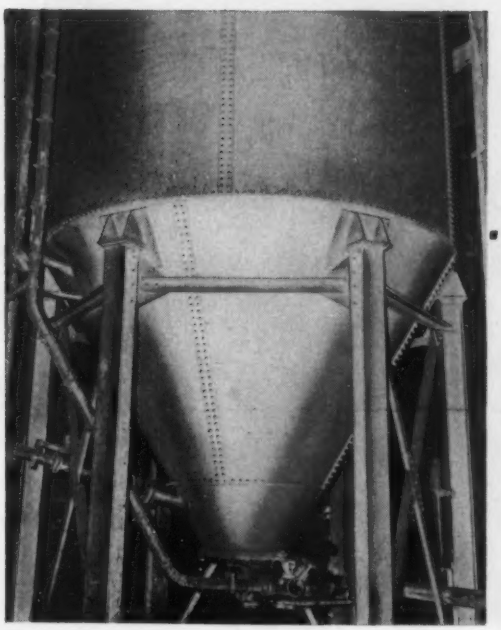
That's why *lead* has long been a "first choice" material in much of the equipment used for treating phosphate rock with sulfuric acid to produce phosphoric acid. It is used for lining vessels and tanks, in piping and pumps, in evaporator coils and for raking blades in agitators.

Recently new forms of cage-type sheet *lead* structures, new bonding and strap-lining methods, new constructions for high-temperature erosion-corrosion service and automatic stud welding techniques, have increased *lead's* usefulness . . . not only in phosphoric production but in many other applications.



What about *lead* for your own acid handling equipment . . . considered in the light of these new techniques! It's something to think about, and . . .

When you think of Lead . . .



think of National Lead Pressure Vessels

. . . lead-lined to last

Today, National Lead weds *lead* to steel . . . not only in pipe (Tubond®) and fittings (United®) but in massive and complex process and storage and shipping vessels, as well. In this equipment, the union is stronger than the tensile strength of *lead*. Bonded lead linings minimize troubles from vibration and severe and rapid cyclic temperature and pressure changes which can result in blistering, buckling and cracking. Creep is virtually eliminated.

In view of this and other developments, you may want to review your position on *lead-lined* tanks, stills, scrubbers, filters, piping, valves and other corrosion resisting equipment. If so, contact National Lead Company, Lead Lined Products, 111 Broadway, New York 6, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

a clear look . .

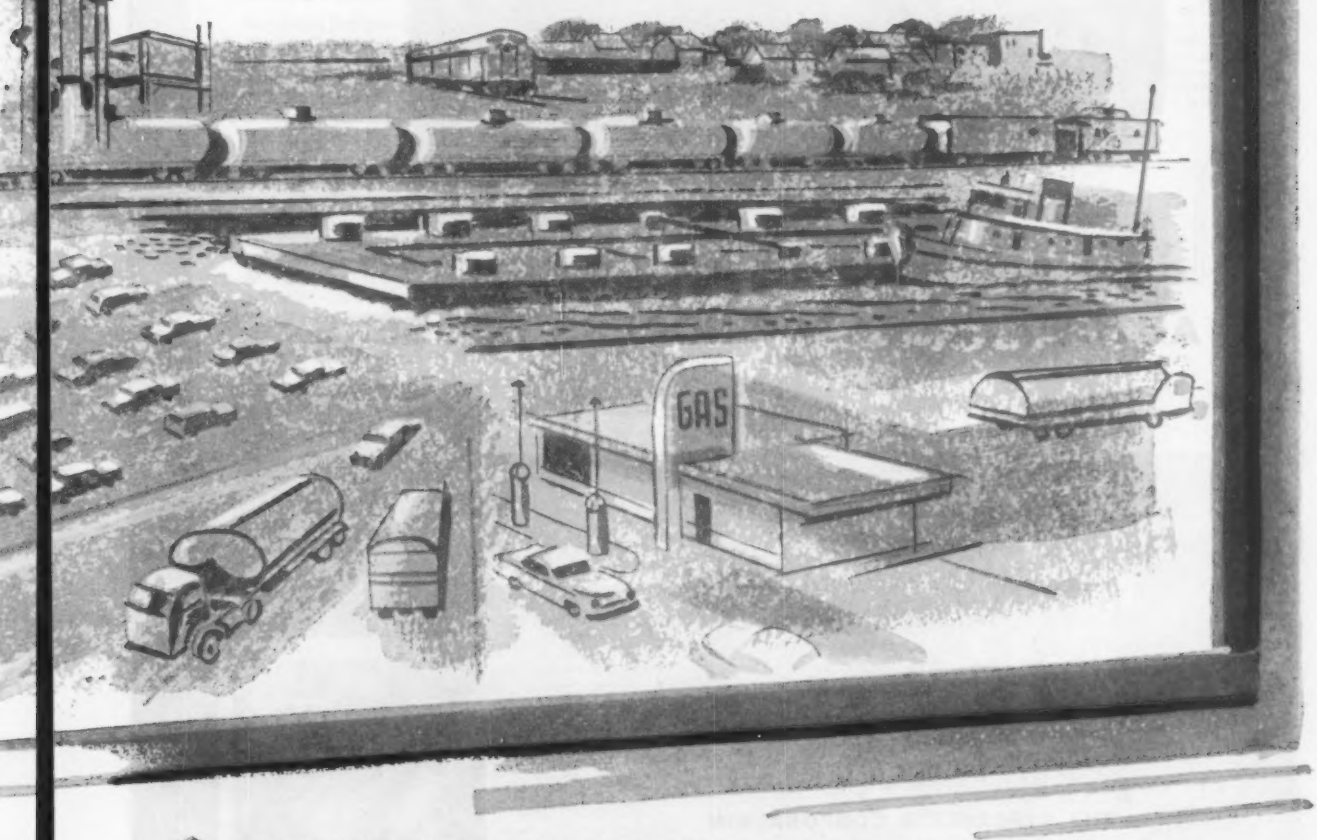
. . . at the economics of

Petroleum Products Marketing

For nearly a half century UOP has been developing and engineering processes for more efficient and more economic production of petroleum products and by-products. Always of primary concern, too, has been the profitable manufacture and marketing of these products by the individual refiner.

Because of this extensive experience Universal is now able to offer the industry the services of a highly qualified marketing and economic research group to help refiners, established or potential, plan intelligently for future development.

This service is comprehensive. It includes such factors as designation of profitable markets, sales potentials, organization and installation requirements, plant locations, product and by-product determination, facilities and raw material supply, manpower and transportation availabilities, financial requirements, projected yields . . . a full and careful analysis of *all* the factors involved in manufacturing and marketing petroleum products. The service is available to any refiner, anywhere, regardless of the volume or scope of his operation.



UOP

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U. S. A.

More Than Forty Years Of Leadership In Petroleum Refining Technology

For more data on advertised products, use Readers' Service Cards, last page.

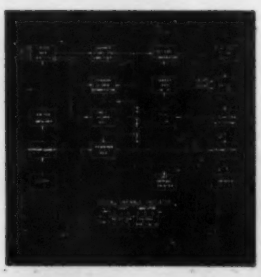
KYBERNETES®

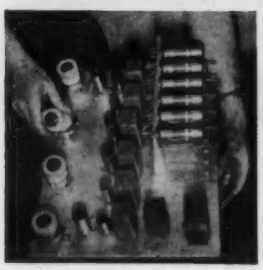
THE KYBERNETES CORPORATION

Division of Self Winding Clock Company, Inc.
for 70 years leader in time standards
and precision engineering

ALL ELECTRONIC LINE OF AUTOMATIC DATA PROCESS LOGGERS

A revolutionary engineering concept, the
Kybernetes Electronic Data Logger
puts to use designs largely predicated
upon advanced techniques
developed by the computer industries,
featuring reliability and accuracy.





Write for Bulletin '108'

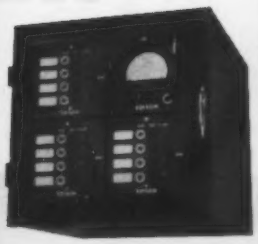
THE KYBERNETES CORPORATION

Executive Offices:
9 East 40th Street
New York 16, N. Y.
MUrray Hill 3-6030

KYBERNETES®

For more data on advertised products, use Readers' Service Cards, last page.

EDISON'S OMNIGUARD continuous temperature monitoring offers absolute dependability



Can be supplied for any type of annunciator or telemetry system

Edison has the answer to prohibitive pumping station and plant shutdown due to motor, generator or pump bearing failure. It's Edison's Omniguard, devised to detect and warn of excessive temperatures well in advance of danger points **with absolute dependability.** The use of Omniguard means the saving of thousands of dollars in downtime and maintenance man hours.

Here's how Omniguard works: easy-to-install resistance temperature detectors are inserted into the equipment to be monitored and are wired directly into the central control unit as one leg of a simple Wheatstone bridge circuit. No electronic circuits, moving parts, adjustments, or maintenance is involved in this fail safe instrument. As soon as a temperature rise occurs the mechanism is automatically shut off and an annunciator of any type (proximate or remote including telemetry) signals the warning.

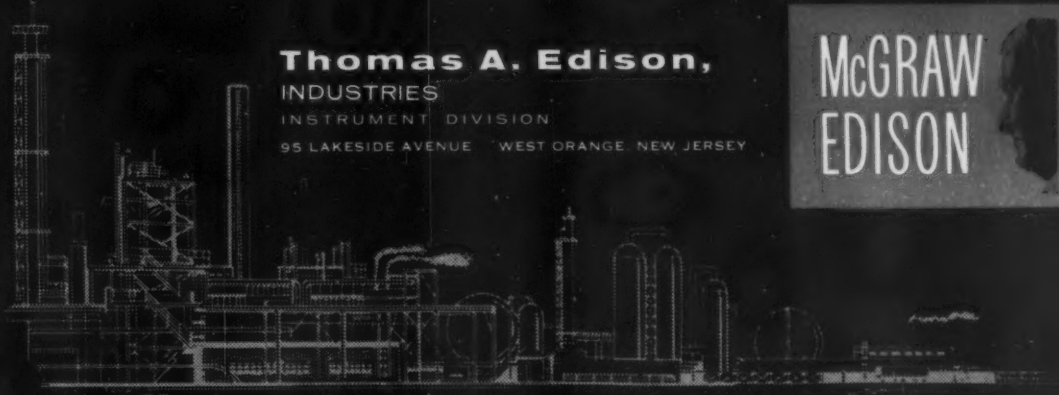
Omniguard can monitor from four to four hundred points with the simple addition of building block units; each point is independently circuited so that Omniguard continues to monitor if other points are shut down. Critical temperatures exist everywhere in the petroleum industry — from remotely unattended pipeline stations to catalytic "crackers," where processes are in motion, or where machinery is in operation. Learn how Omniguard can save you money initially — costs less than any other system available — and thereafter — eliminates downtime, maintenance and manual inspection of equipment.

Write and tell us about your particular temperature monitoring problem.

SPECIFICATIONS:

Voltage:	115 volts, 50 cycles
Power drain:	25 VA maximum
Voltage error:	±2°F. maximum from 100 to 130 volts
External alarm:	1 per monitor. Contact rating 150 watts or 3 amp. non-inductive load

Indicator requires no electrical connections. Power and resistance reading is carried through reeled cord when plugged into jack in face of monitor.



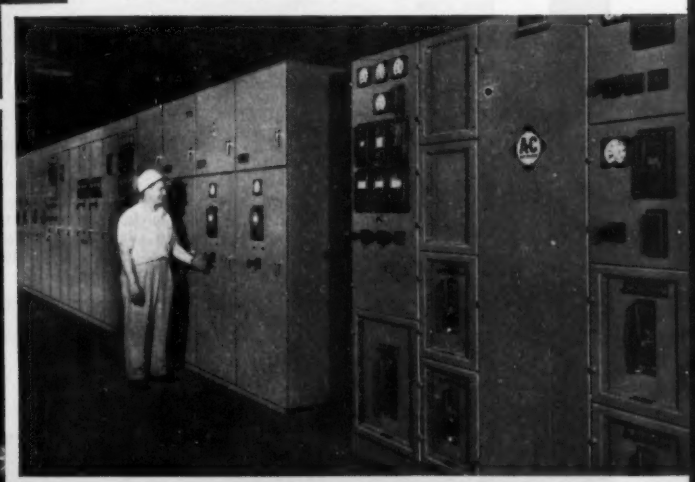
Thomas A. Edison,
INDUSTRIES
INSTRUMENT DIVISION
95 LAKESIDE AVENUE WEST ORANGE NEW JERSEY

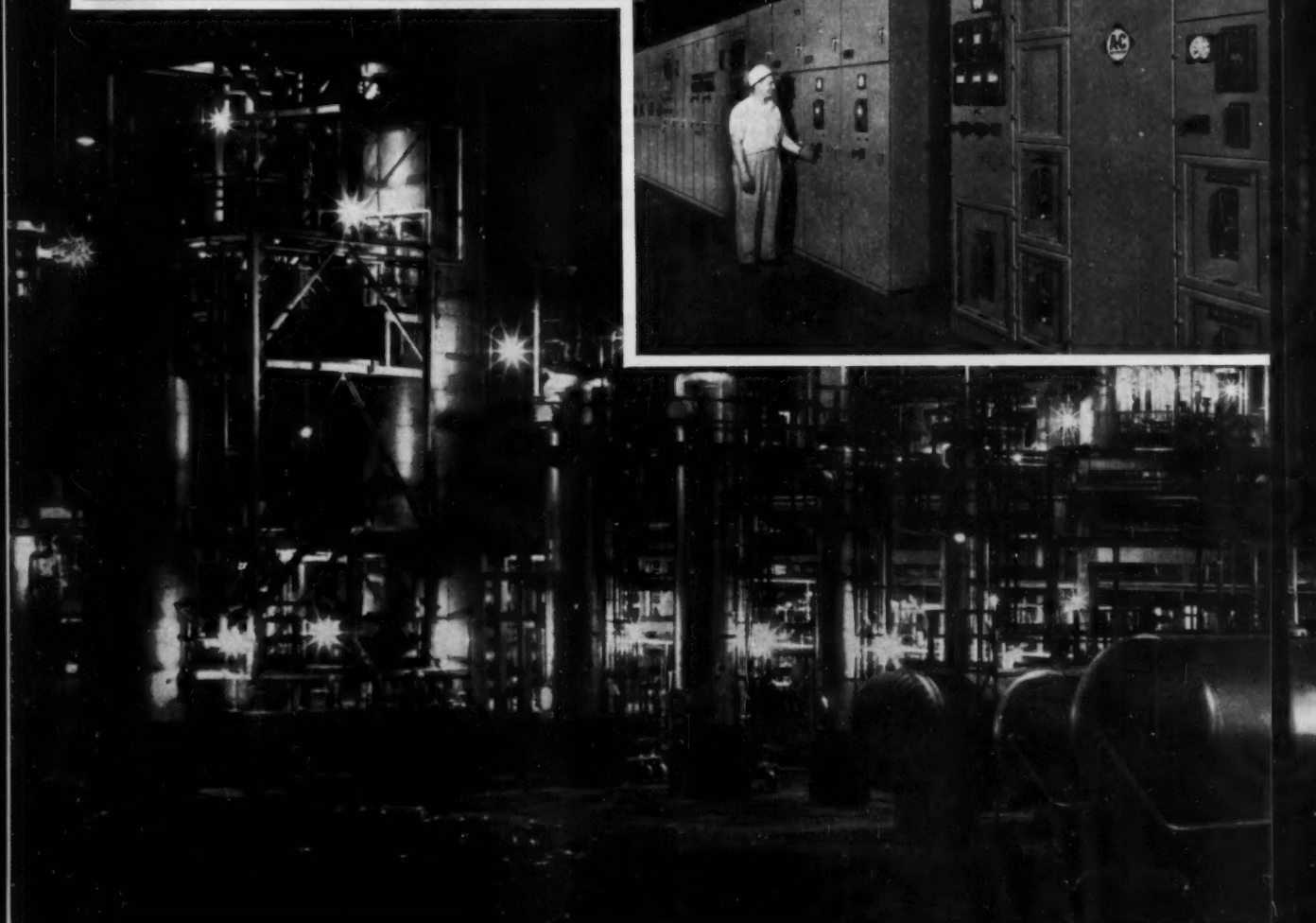
McGRAW EDISON

For more data on advertised products, use Readers' Service Cards, last page.

RELIABLE CONTROL

Allis-Chalmers motor control in the "Refinery of the future"





More than 125 Allis-Chalmers high voltage motor controllers provide continuity of service in Tidewater's ultra-modern refinery near Delaware City.

for continuous service

MAXIMUM round-the-clock motor protection forms a major portion of the Allis-Chalmers contribution to the world's most modern refinery. The Tidewater Oil Company selected Allis-Chalmers control to help provide the reliable, uninterrupted service needed to meet a 130,000-bbl-per-day output.

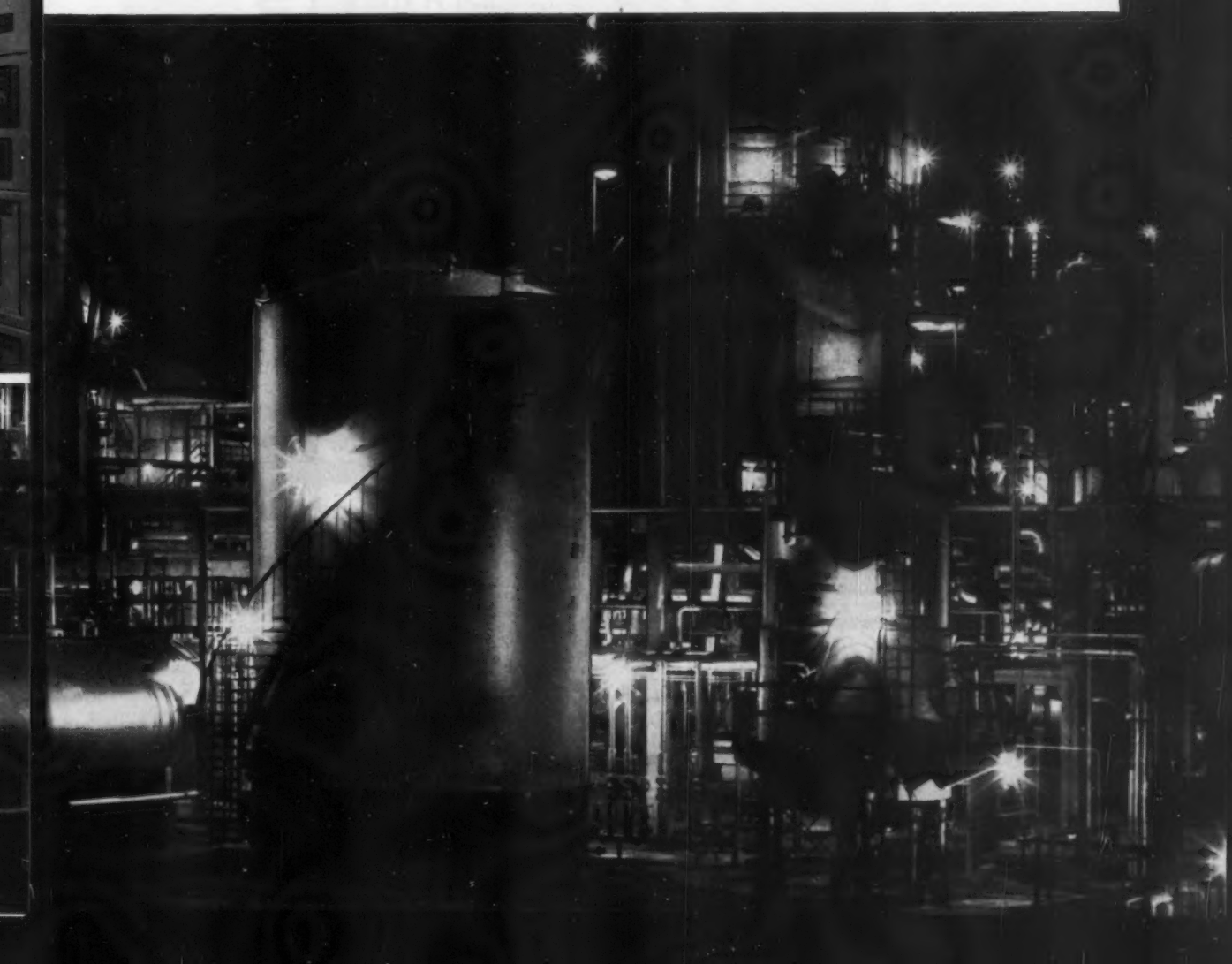
Tidewater's Delaware Refinery is another major petroleum installation depending on Allis-Chalmers control for continuous day and night operation. This growing trend reflects industry confidence in Allis-Chalmers modern controllers for petroleum requirements.

For more information about how Allis-Chalmers experience in the petroleum industry can help you, contact your nearby A-C sales office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5430



Tidewater Oil Company Refinery. This night scene shows the 130,000-bbl-per-day crude unit, where uninterrupted service is vital to successful operation.

protection with KONTOL

INCREASES RUN TIME 33⅓%*

In a midcontinent refinery atmospheric tower the effects of Kontol corrosion control were carefully compared to previous 6 month refinery runs. During the former runs, corrosion control was attempted by injecting ammonia into the atmospheric tower overhead to maintain a pH of about 7 in the overhead accumulator water. The run with Kontol was identical except that running time was increased from 6 to 8 months.

Operations during both runs were observed by refinery personnel and results reported as follows:

INSPECTION DEPARTMENT

Metal loss in test plugs (vapor line, crude-to-vapor heat exchanger):
Without Kontol, Plug "A", 0.10 inches
Without Kontol, Plug "B", 0.05 inches
With Kontol, Plug "A", 0.01 inches
With Kontol, Plug "B", 0.02 inches

Exchanger Fouling:
Visual inspection showed a decrease of 80-90% in fouling with Kontol in use.

Tower Trays:
Without Kontol, 8 manhours cleaning time
With Kontol, no cleaning required

OPERATING DEPARTMENT

Heat Transfer Rates at 1500 bbls/hr charge rate:
Without Kontol, exchanger crude outlet temperature, 187° F
With Kontol, exchanger crude outlet temperature, 192° F

Heat Transfer Rates at 1000 bbls/hr charge rate:
Without Kontol, exchanger crude outlet temperature, 210° F
With Kontol, exchanger crude outlet temperature, 231° F

LABORATORY DEPARTMENT

Iron count, atmospheric tower overhead water:
Without Kontol, 6.1 ppm
With Kontol, 2.2 ppm*

*During first week of Kontol applications iron count averaged 100 ppm, indicating the sloughing off of fouling materials effected by Kontol's detergent action.

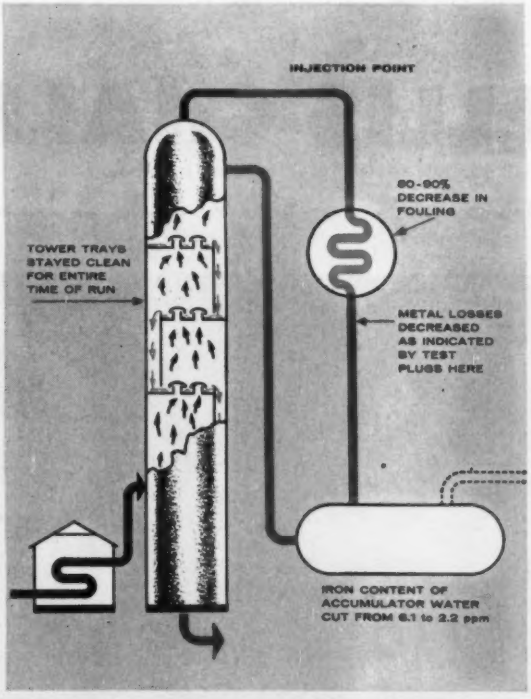
As a result of the data on these two refinery runs, the refinery personnel concerned recommended the use of Kontol be extended to all points where fouling due to iron sulfide might occur in exchangers and towers.

It also "Reduced heat exchanger fouling 80-90%"

"Improved heat transfer rates"

"Made tray cleaning unnecessary"

**Resulted in the longest run on record at this refinery*


INJECTION POINT
80-90% DECREASE IN FOULING
TOWER TRAYS STAYED CLEAN FOR ENTIRE TIME OF RUN
METAL LOSSES DECREASED AS INDICATED BY TEST PLUGS HERE
IRON CONTENT OF ACCUMULATOR WATER CUT FROM 6.1 to 2.2 ppm

TRETOLITE COMPANY
A DIVISION OF PETROLITE CORPORATION
369 Marshall Avenue, St. Louis 19, Missouri
5515 Telegraph Rd., Los Angeles 22, California

Leading refiners everywhere rely on Kontol for preventing corrosion difficulties. Your Tretolite Refinery Service Engineer is always available for consultation. Call him today or write for complete information.

Chemicals and Services for the Petroleum Industry

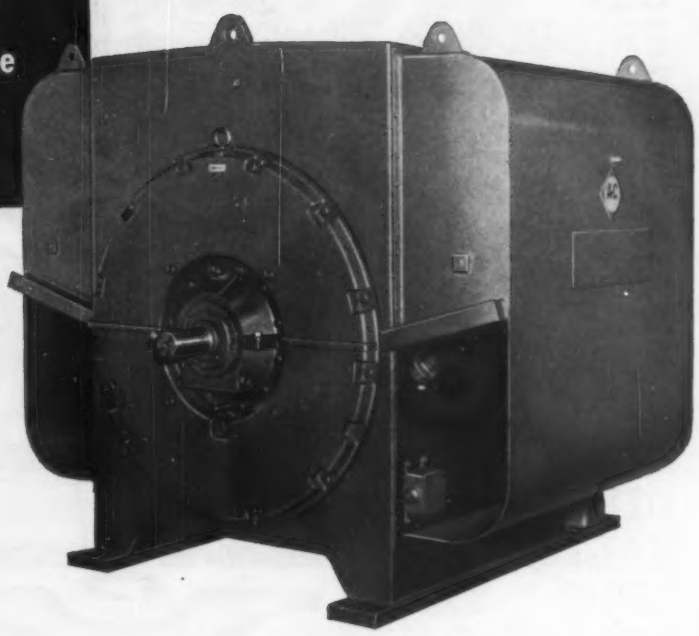
DESALTING • DEMULSIFYING • CORROSION PREVENTING • WATER DE-OILING • SCALE INHIBITING
METAL DEACTIVATING • ASPHALT ANTI-STRIPPING

R-57-2

For more data on advertised products, use Readers' Service Cards, last page.

Eliminate costly enclosures with Allis-Chalmers weather-protected MOTORS

Modern features cut operating, maintenance expense . . . give MORE dependability



Here's a newly designed line of Allis-Chalmers weather-protected motors with the ability to "take" outdoor conditions. This means no expensive protective enclosures are needed . . . a big saving in plant or installation building costs.

Designed to meet defined NEMA requirements, these motors incorporate many important features which assure dependable outdoor operation:

- **Ventilating System** — Low velocity intake, vertical lift, change of direction and high velocity discharge of ventilating air keep rain, snow, sleet, dust and dirt out of vital parts.
- **Removable Air Ducts** — To facilitate inspection and maintenance of interior air passages, air intake ducts are designed for quick removal.
- **Stator Assembly** — Removable as a unit, it simplifies maintenance and minimizes downtime.
- **Split Sleeve Bearings** — Capsulized design permits access to motor interior without disturbing the bearings or their enclosures. Positive vapor seal is used on high-speed motors. Antifriction bearings are available for slow speed motors.
- **Proven Insulation** — Famous Allis-Chalmers insulation systems (Class A and B) are available. And, for extreme temperatures, or where high resistance to abrasion and moisture is required, Allis-Chalmers can provide the revolutionary *Silco-Flex* system.

Silco-Flex is an Allis-Chalmers trademark.

THIS DESIGN available in ratings from 250 to 900 hp. Other designs in larger horsepower ratings are also available. Contact your A-C sales office or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin. Ask for Bulletins 51B8606A and 05B7894.

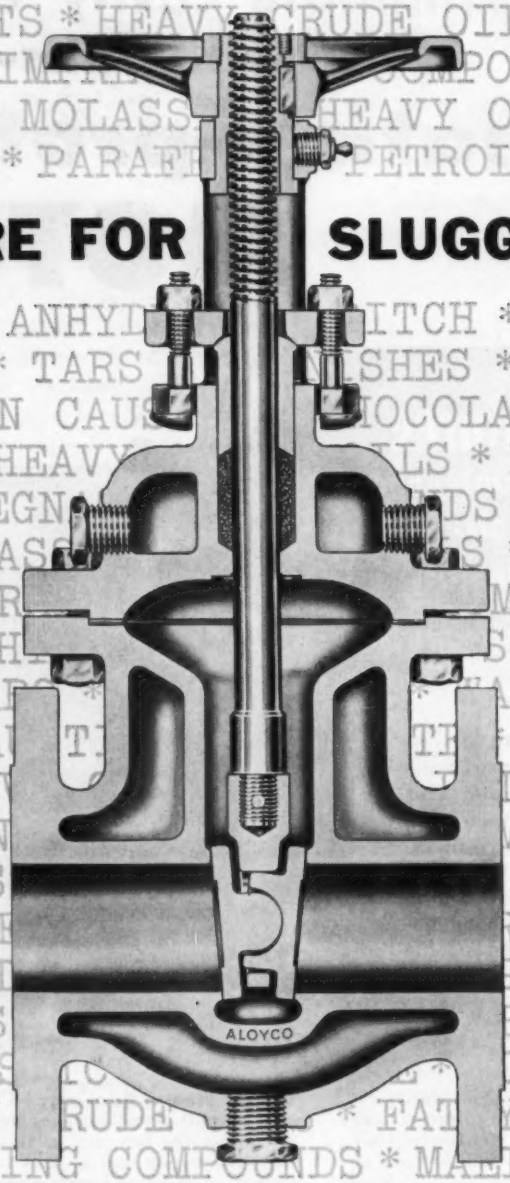
A-5292

ALLIS-CHALMERS

ASPHALT * MOLTEN CAUSTIC * CHOCOLATE * COAL TAR PRODUCTS * HEAVY CRUDE OILS * FATTY ACI DS * GUMS * IMPREGNATING COMPOUNDS * MAELIC ANHYDRIDE * MOLASSES * HEAVY OILS * HYDROGE NATED OILS * PARAFFIN * PETROLEUM RESIDUES

SURE CURE FOR SLUGGISH FLUIDS

* PHTHALIC ANHYDRIDE * PITCH * SOAPS * MOLTEN SULFUR * TARS * ASHES * WAXES * ASPHALT * MOLTEN CAUSTIC * CHOCOLATE * COAL TAR PRODUCTS * HEAVY CRUDE OILS * FATTY ACIDS * GUMS * IMPREGNATING COMPOUNDS * MAELIC ANHYDRIDE * MOLASSES * HYDROGENATED OILS * PARAFFIN * PETROLEUM RESIDUES * PHTHALIC ANHYDRIDE * SOAPS * MOLTEN SULFUR * TARS * WAXES * ASPHALT * MOLTEN CAUSTIC * COAL TAR PRODUCTS * HEAVY CRUDE OILS * FATTY ACIDS * GUMS * IMPREGNATING COMPOUNDS * MAELIC ANHYDRIDE * MOLASSES * HYDROGENATED OILS * PARAFFIN * PETROLEUM RESIDUES * PHTHALIC ANHYDRIDE * SOAPS * MOLTEN SULFUR * TARS * ASPHALT * MOLTEN CAUSTIC * COAL TAR PRODUCTS * HEAVY CRUDE OILS * FATTY ACIDS * GUMS * IMPREGNATING COMPOUNDS * MAELIC ANHYDRIDE



COMPLETELY JACKETED ALOYCO VALVES

Aloyco Jacketed Valves are the surest way to keep slow moving corrosives flowing because they maintain higher temperatures than valves heated by other methods.

Jacketed valves are made in a variety of sizes and pressures and are furnished with convenient inlet and outlet holes for heating with steam or other media. They are available in 18 8S, 18 8SMO, Aloyco 20 and other analyses to specification.

The broad Aloyco Valve line includes Jacketed Gate (above) Globe and Check Valves, the first Jacketed Valves ever integrally cast in high alloys. One more indication of Aloyco's leadership in pattern making, foundry techniques and engineering skills. Long experience in these areas has made Aloyco the world's foremost specialist in Stainless Steel Valves.

Ask Aloyco's Corrosion Engineering Service to work with you on your valve problems. Alloy Steel Products Company, 1303 West Elizabeth Avenue, Linden, New Jersey. 7.12

ALLOY STEEL PRODUCTS COMPANY

THE NAME TO WATCH IN

HEAT TRANSFER EQUIPMENT

YUBA HEAT TRANSFER DIVISION

HEAT EXCHANGER DIVISION OF

formerly THE **LUMMUS** COMPANY

Important to every user of heat transfer equipment is the acquisition of the Heat Exchanger Division of The Lummus Company by Yuba Consolidated Industries, Inc. The management, sales and engineering personnel, as well as the designs, patents, and manufacturing facilities of the former Lummus operation at Honesdale, Pennsylvania, are now part of the YUBA nation-wide organization. YUBA is proud of the opportunity to identify its name with the long established recognition enjoyed by Lummus in the power industries, as well as in the chemical and petroleum processing fields. The continuing pioneering development for which Lummus has been known, and its existing commitments and obligations, will be carried forward in every phase under the YUBA name. For your current and future requirements consult YUBA first.

YUBA HEAT TRANSFER DIVISION

YUBA
CONSOLIDATED INDUSTRIES, INC.

General Sales Offices and Plant—Honesdale, Pennsylvania
Eastern Division Sales Office—385 Madison Ave., New York, N.Y.
Other Yuba Consolidated Industries, Inc. Plants: Buffalo, N.Y. • Richmond, Calif. • Benicia, Calif.

NATION-WIDE SALES REPRESENTATION IN PRINCIPAL CITIES

For more data on advertised products, use Readers' Service Cards, last page.

Keep areas weed-free . . . avoid fire hazards

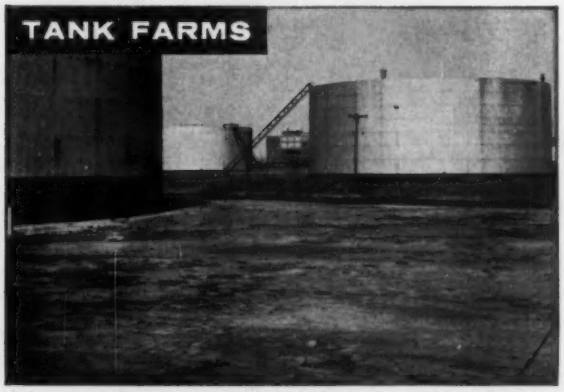
Spray Du Pont TELVAR®
WEED KILLERS
just once for season-long weed control

You can eliminate weeds and grasses that create fire hazards and that make maintenance difficult and costly. Just one spray of Du Pont "Telvar" controls weeds for a season or longer. "Telvar" kills weeds through the roots, then remains in the soil to provide residual action long after the initial spray is applied. Low dosages save you cost, handling and storage space. "Telvar" weed killers are non-corrosive to equipment, non-volatile, low in toxicity to humans and animals. For low-cost, long-term control of weeds, include "Telvar" in your maintenance program.

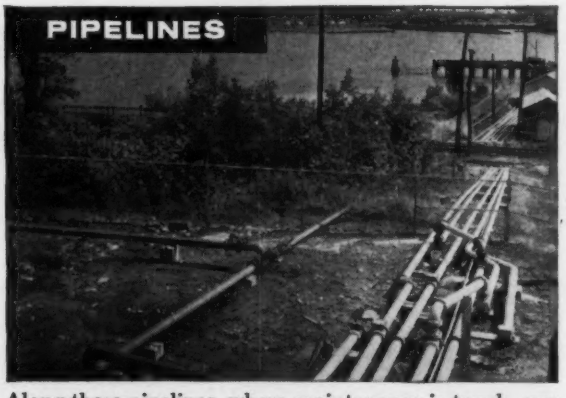
TELVAR®
Monuron and Diuron
WEED KILLERS

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Note the excellent control of weeds and grasses around this wellhead from just one application of "Telvar."



The treated area around this tank farm has remained weed-free for an entire season.



Along these pipelines, where maintenance is tough, one application of "Telvar" has kept the treated area weed-free for a year.

On all chemicals, follow label instructions and warnings carefully.

For more data on advertised products, use Readers' Service Cards, last page.

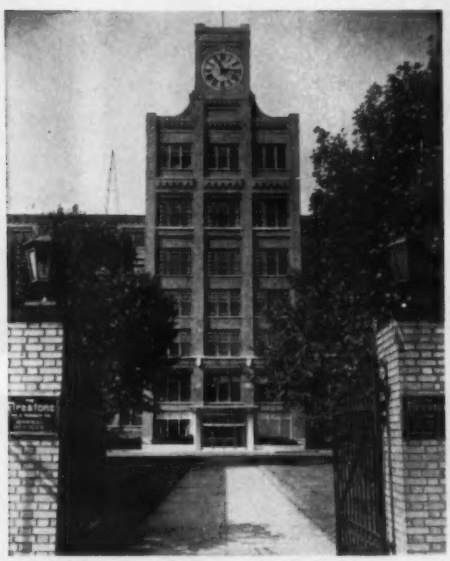
Water Supply a Problem?

Large or Small.... You can Count on Layne!

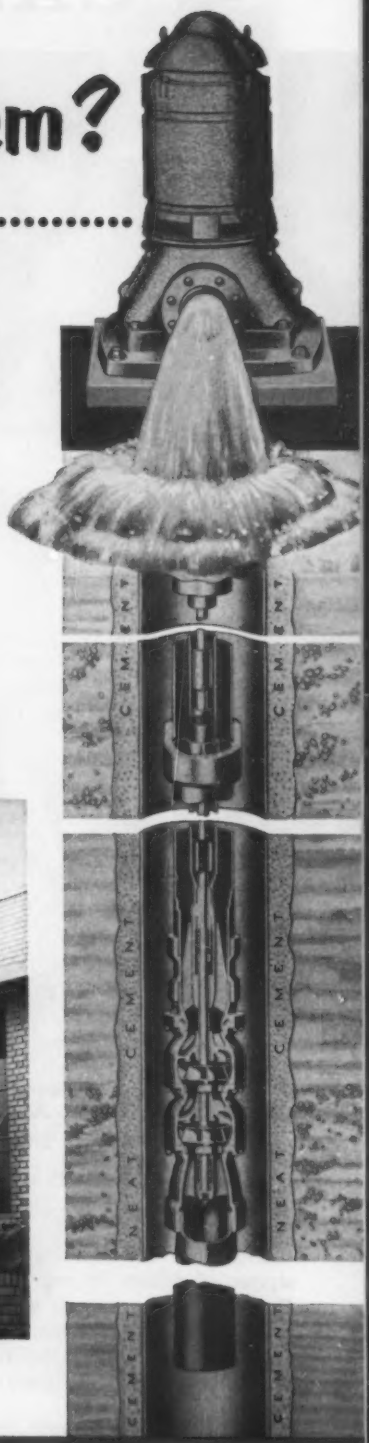
To Layne Engineers there are no small jobs. Some are just larger than others. Whether your industrial business needs 30 gallons per minute, or 30,000 gallons per minute, the delivery and quality of your water needs, when you need it, is what counts . . . and you can count on Layne!

Each installation requires the same research, the same calculations, the same truthful recommendations. Layne provides the same careful attention to every industrial water problem. Layne is concerned with just one thing . . . . the unfailing and economical delivery of water in the required quantities and desired quality . . . and you can count on Layne!

Write for our General Services Bulletin Number 100.



Firestone Rubber Company of Akron, Ohio, or Baxter Company of Cleveland, Miss., both industries require and receive the same attention regardless of their water needs. When you need water . . . you can count on Layne!



1882 — 1957
Layne
75 YEARS OF PROGRESS

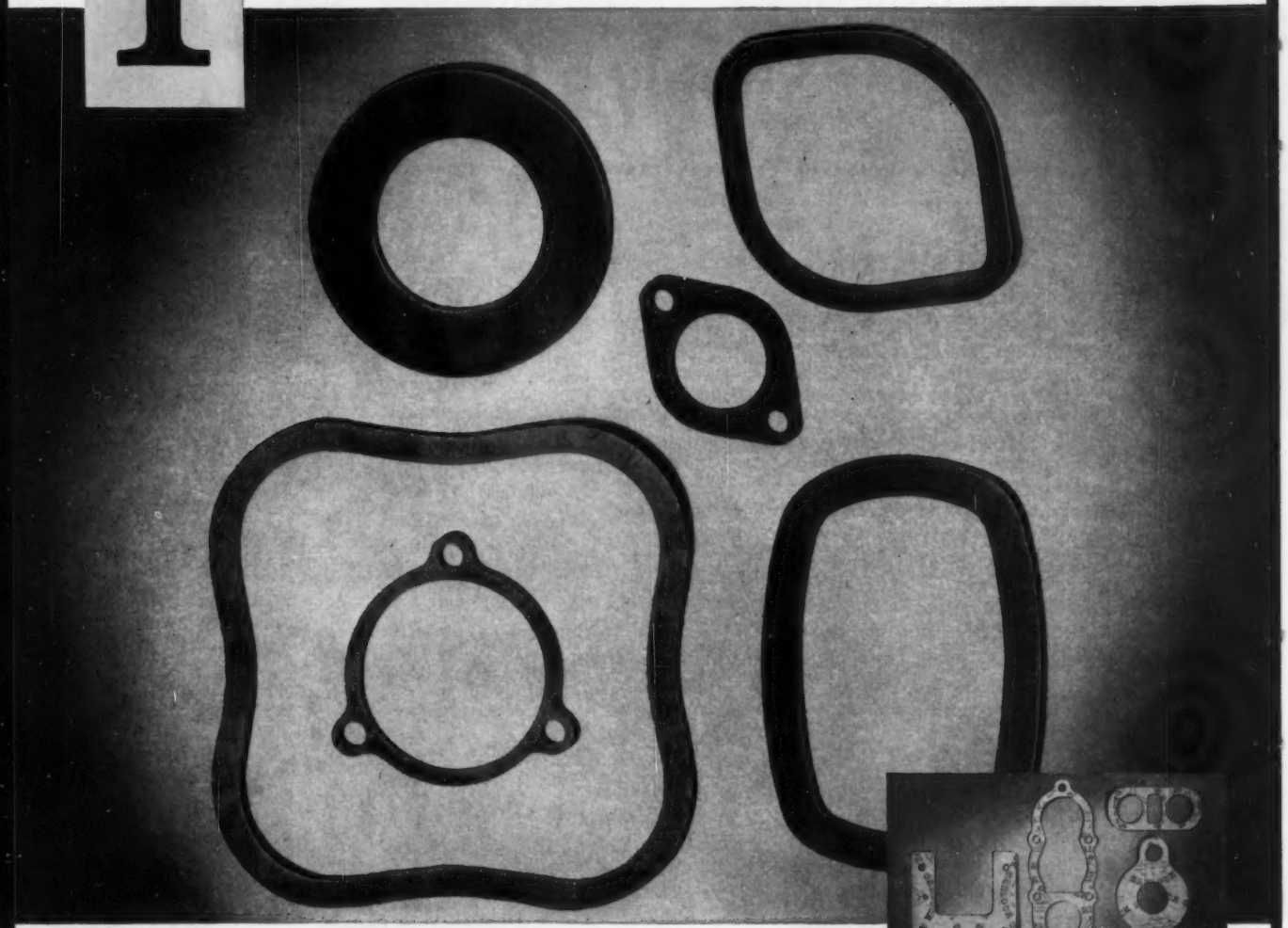
WATER WELLS • VERTICAL TURBINE PUMPS • WATER TREATMENT

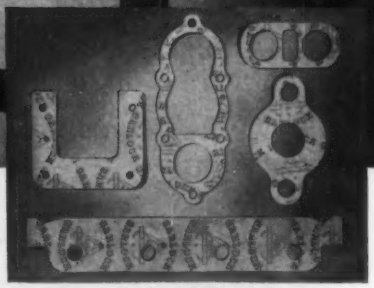
LAYNE & BOWLER, INC. MEMPHIS

General Offices and Factory • Memphis 8, Tennessee

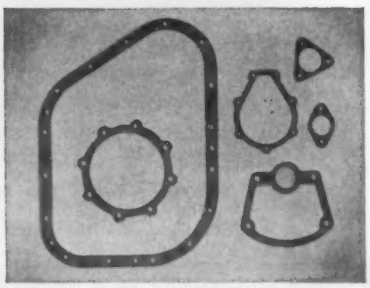
LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD

1 GASKET OR 1,000,000





Rubber Gaskets



Cork-Fibre Gaskets

GARLOCK can supply all types of gaskets in any quantity...

Garlock has the facilities to die cut, hand cut, mold or machine all sizes and shapes of gaskets in any quantity. Yes, whether you are a small or big user, Garlock can supply you with the proper gaskets made accurately to your blueprint specifications or template.

There's a Garlock gasket that answers your every requirement efficiently and economically. Some of the most widely used Garlock gasketing materials are:

- Compressed Asbestos with rubber, neoprene or buna-N binder
- Woven Asbestos
- Rubber—plain, cloth inserted or wire inserted
- Buna-N
- Thiokol—plain or cloth inserted
- Silicone—plain or or cloth inserted
- "Teflon"
- Neoprene—plain or cloth inserted
- Vegetable Fibre
- Cork-Fibre
- Asbestos—metallic
- Leather

THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, *contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.*

Remember

. . . these gaskets are only part of "the Garlock 2,000" . . . two thousand different styles of gaskets, packings and seals to meet all your needs . . . the only complete line available. That's why you get unbiased recommendations from your Garlock representative. Call him today.

GARLOCK

Packings, Gaskets, Oil Seals, Fluorocarbon Products, Mechanical Seals, Rubber Expansion Joints

you can meet any lubrication specification if you

BLEND WITH ENJAY PARATONE®

(VISCOSITY-INDEX IMPROVERS)

Base stocks blended with Enjay Paratone can be compounded into lubricants combining cold-weather quick starting properties with high temperature, low consumption characteristics. These lubricants are *all-season* oils, featuring improved gas mileage. More and more refiners and blenders are relying exclusively on Paratone to produce the high "VI" required in these all-season oils.

Through years of intensive research and development work with automotive manufacturers, Enjay has developed the only *complete line* of high quality additives (Paramins®) that can assure *maximum* performance characteristics. Why not let this experience and know-how work for *you*? Write, wire or phone the Enjay Company.

ENJAY

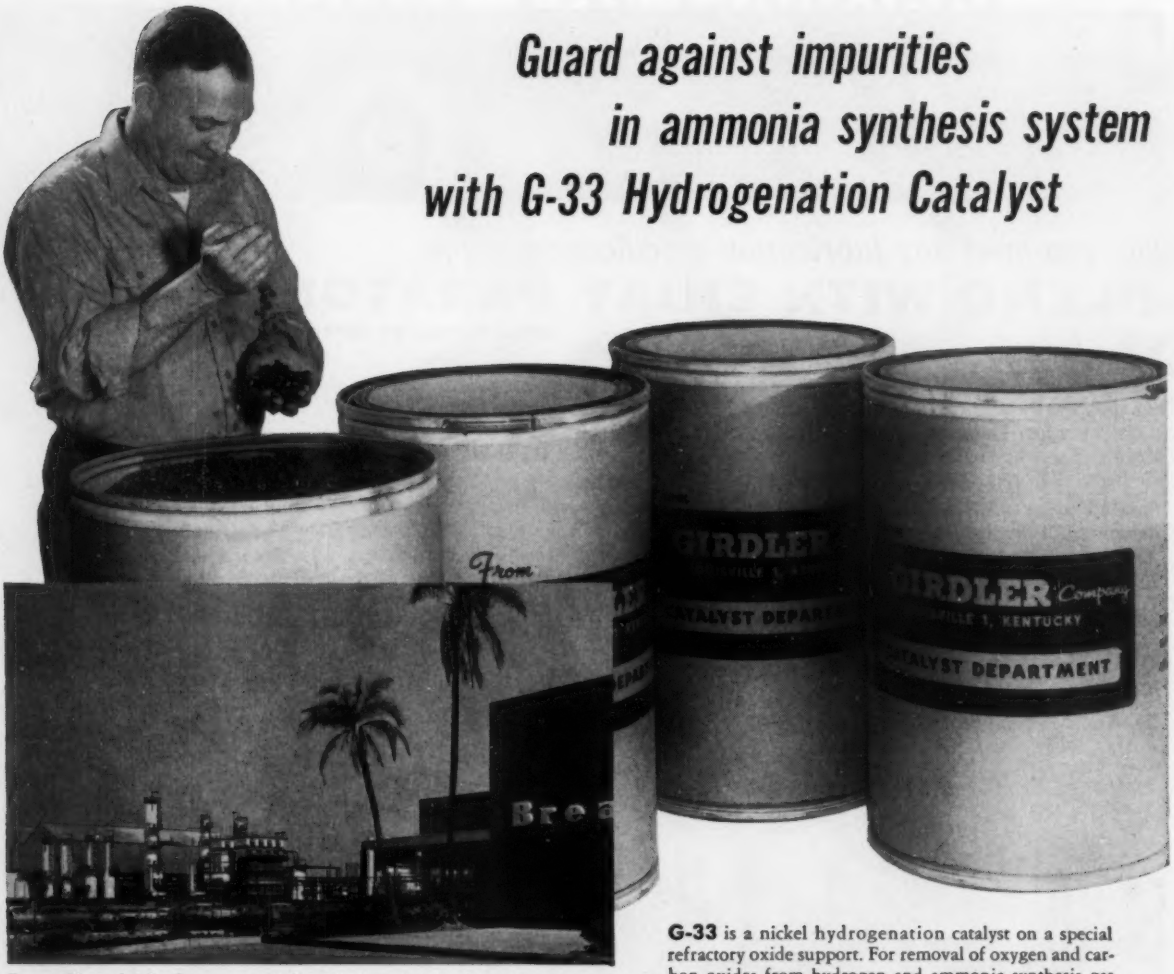
Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 WEST 51st ST., NEW YORK 19, N. Y.

Akron • Boston • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

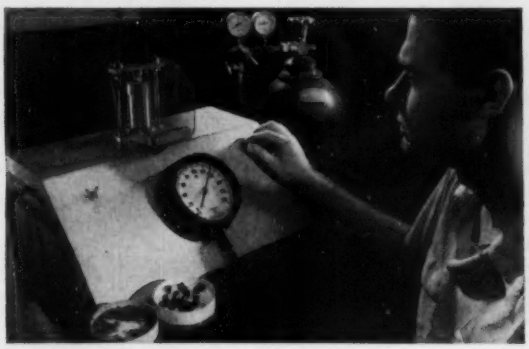
For more data on advertised products, use Readers' Service Cards, last page.

Guard against impurities in ammonia synthesis system with G-33 Hydrogenation Catalyst



Brea Chemicals, Inc., uses Girdler G-33 catalyst in the methanators to remove oxygen and carbon oxides in the feed gas to the ammonia synthesis system. This catalyst not only smooths out normal fluctuations in purity of the synthesis gas, but also protects the stream from abnormal concentrations of impurities which may result from upsets in the system.

G-33 is a nickel hydrogenation catalyst on a special refractory oxide support. For removal of oxygen and carbon oxides from hydrogen and ammonia synthesis gas streams where the catalyst may be subjected to *severe physical stress.* Also used for hydrogenation of organic compounds such as aldehydes, ketones and aromatics.



Physically rugged. G-33 catalyst must be able to perform under stresses induced by liquid or mixed phase operations. Girdler makes extensive analyses of physical properties to assure adequate strength. Write for bulletin on Girdler catalysts.

Want better performance? Girdler's continuing program of catalyst improvement, high standards of quality control, and experience in solving catalyst problems can help improve *your* processing.

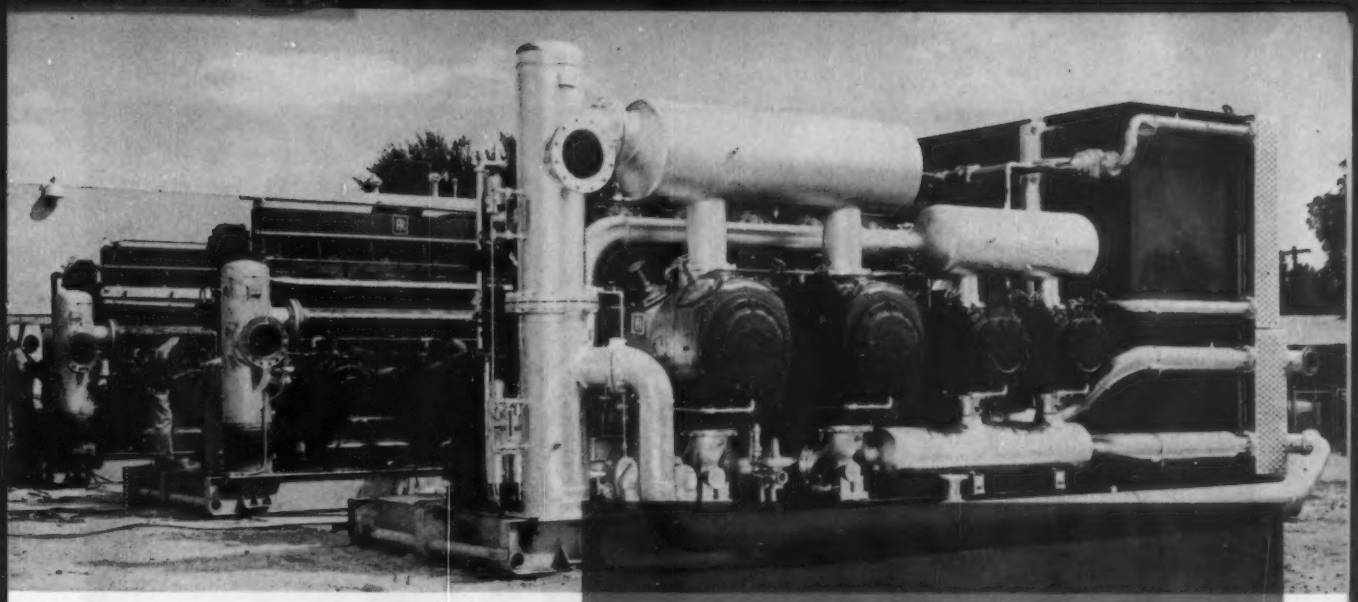
CATALYST DEPARTMENT

GIRDLER MANUFACTURES CATALYSTS FOR:
HYDROGENATION • SYNTHESIS GASES AND HYDROGEN GENERATION • DESULFURIZATION • NEW CATALYTIC PROCESSES

the GIRDLER Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY



THERE'S MORE FLEXIBILITY IN THESE PACKAGE COMPRESSORS

Stearns-Roger's extensive manufacturing facilities and gas engineering personnel are exclusively responsible for your packaged compressor plant, from quotation to on-site operation. Our complete service assures you of a plant "custom built" to utmost efficiency and economy for the precise conditions of your field.

Each rugged, compact unit, with the compressor of your choice, is completely design-engineered just as are much larger permanent field installations. Stearns-Roger Packaged Compressor Plants provide quick, easy installation and substantially automatic operation. For every important service — process engineering, custom fabrication, field erection...

Ask for our Packaged Compressor Plant Bulletin, covering units from 100 H.P. up.

TAKE IT UP WITH

Stearns-Roger

THE STEARNS-ROGER MFG. CO. • DENVER, COLORADO

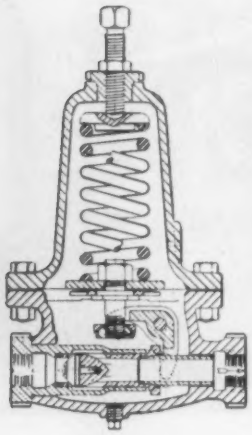
DENVER • HOUSTON • EL PASO • SALT LAKE CITY

Stearns-Roger Engineering Co., Ltd. Calgary

For better molded products...

CASH STANDARD type 1000 VALVES

keep mold temperatures in the "Safety Zone"



In the production of molded parts, uniform quality is assured through careful control of time, temperature, pressure and other factors in the molding cycle.

A leading producer of precision molded plastics parts is General Electric Company's Plastics Department, Decatur, Ill. On G-E's compression molding machines, almost 200 Cash Standard Type 1000 Reducing Valves are in use, keeping mold temperatures constant by controlling the steam supply.

Donald F. Thompson, G-E's Supervisor of Plant and Facilities Engineering, says: "For our particular application, where we use a large number of reducers, it is essential that the initial cost and maintenance cost be held to a minimum. We have found that Cash Standard 1000's have done the job very effectively."

The unique construction of this valve provides high capacity and accurate control of steam, water, air, oil and most gases and chemicals. Exclusive streamlined inner valve eliminates turbulence; flow through valve housing is in a straight uninterrupted line; an aspirating effect controls valve opening by amplifying slight pressure changes into large valve operating forces.

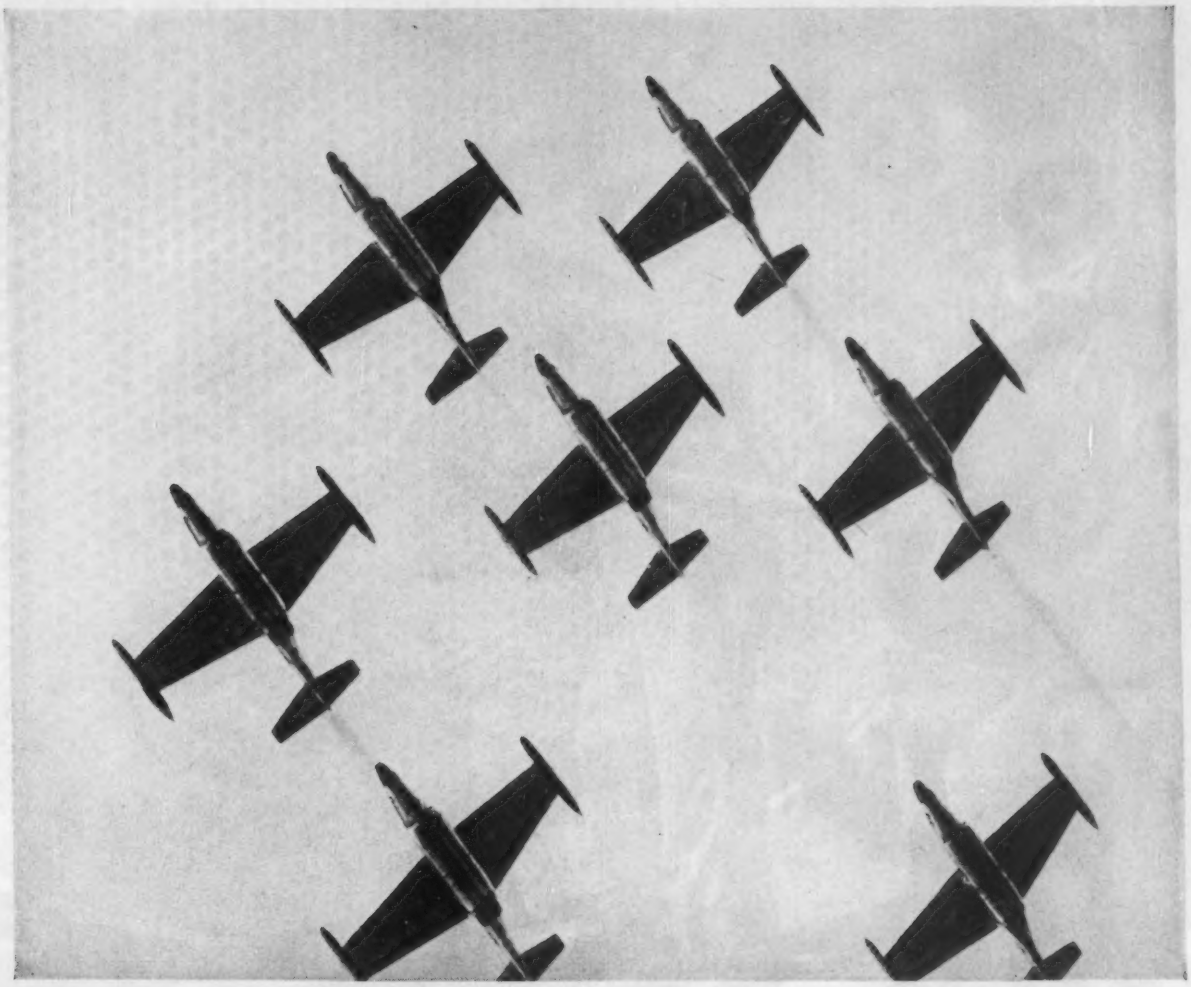
What's *your* control problem? Contact the Cash Standard control specialist in your area for more information on this unusual valve and other Cash Standard control products, or write Dept. L.

CASH CS STANDARD

A. W. Cash Co. and Its Subsidiary, Cash Standard Stacon Corp.
P. O. Box 551, Decatur, Ill.

Pressure, Hydraulic, Temperature, Process and Combustion Controls

For more data on advertised products, use Readers' Service Cards, last page.



Reaching For The Sky But

STILL TIED TO THE GROUND

Reaching for the sky, this modern jet plane is dependent on the nation's refineries to provide the specialized fuel that is needed to get them there. In 1957, for example, it is estimated that jet fuel requirements will increase by approximately 12 per cent.

Increased demand for petroleum products calls for increased efficiency in refinery operations. That's where Hercules Polyrad comes in.

Polyrad, a filming amine that acts as an inhibitor and detergent, helps maintain throughput, increase heat transfer, and cut down time for maintenance. At turn-around time you see the difference that Polyrad makes.

Stocks of Polyrad are maintained at conveniently located points throughout the country and overseas. We'll be glad to discuss the application of Polyrad to your specific operating conditions.

Pine Chemicals Division, Naval Stores Department
HERCULES POWDER COMPANY
INCORPORATED
976 Market St., Wilmington 99, Del.

REFINERS RELY ON
POLYRAD®
FILMING AMINE INHIBITOR

NA57-4

For more data on advertised products, use Readers' Service Cards, last page.

Any Size...Any Design

Size or complexity makes no difference to the prompt and efficient service that The M. W. Kellogg Company offers to the process industries on heat exchangers. Whether it's an order for a single 14-ft. diameter giant, like the one above, or a group of normal size units, Kellogg's recently expanded facilities are geared to produce to the strictest design standards and delivery schedules. With these facilities, Kellogg can handle the complete job of designing, engineering, and fabricating heat exchangers, or make exchangers to customers' own designs.

FABRICATED PRODUCTS DIVISION

THE M. W. KELLOGG COMPANY

711 THIRD AVENUE, NEW YORK 17, N. Y.

A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Company Limited, Toronto • Kellogg International Corp., London • Kellogg Pan American Corp., New York
Societe Kellogg, Paris • Companhia Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas

HASTELLOY alloys boost life of 3 common equipment items handling 3 common corrosives

Pump made of HASTELLOY alloy B handling sulphuric acid sludge has given long, dependable service at Cities Service Lake Charles, La. Refinery. HASTELLOY alloys are produced and sold by Haynes Stellite Company, Division of Union Carbide Corporation, Kokomo, Indiana.

1 Pump handling sulphuric sludge

Nickel alloy used... HASTELLOY* alloy B.

Kind of service... Pumps kerosene sludge containing 70% sulphuric acid from kerosene treating drum.

The pay-off... *Pump shows no sign of corrosion after 16 months service.*

2 Sieve tray under severe oxidizing conditions

Nickel alloy used... HASTELLOY alloy C.

Kind of service... Tray is part of a Peabody stripper installed at bottom of scrubber tower, right above point where air is blown through 160°F. scrubbing water to reclaim traces of sulphur dioxide. Hot moist air driving up through scrubber causes oxidizing conditions.

The pay-off... *Tray in good condition after nearly a year of service.*

3 Valves handling moist chlorine under pressure

Nickel alloy used... HASTELLOY alloy C.

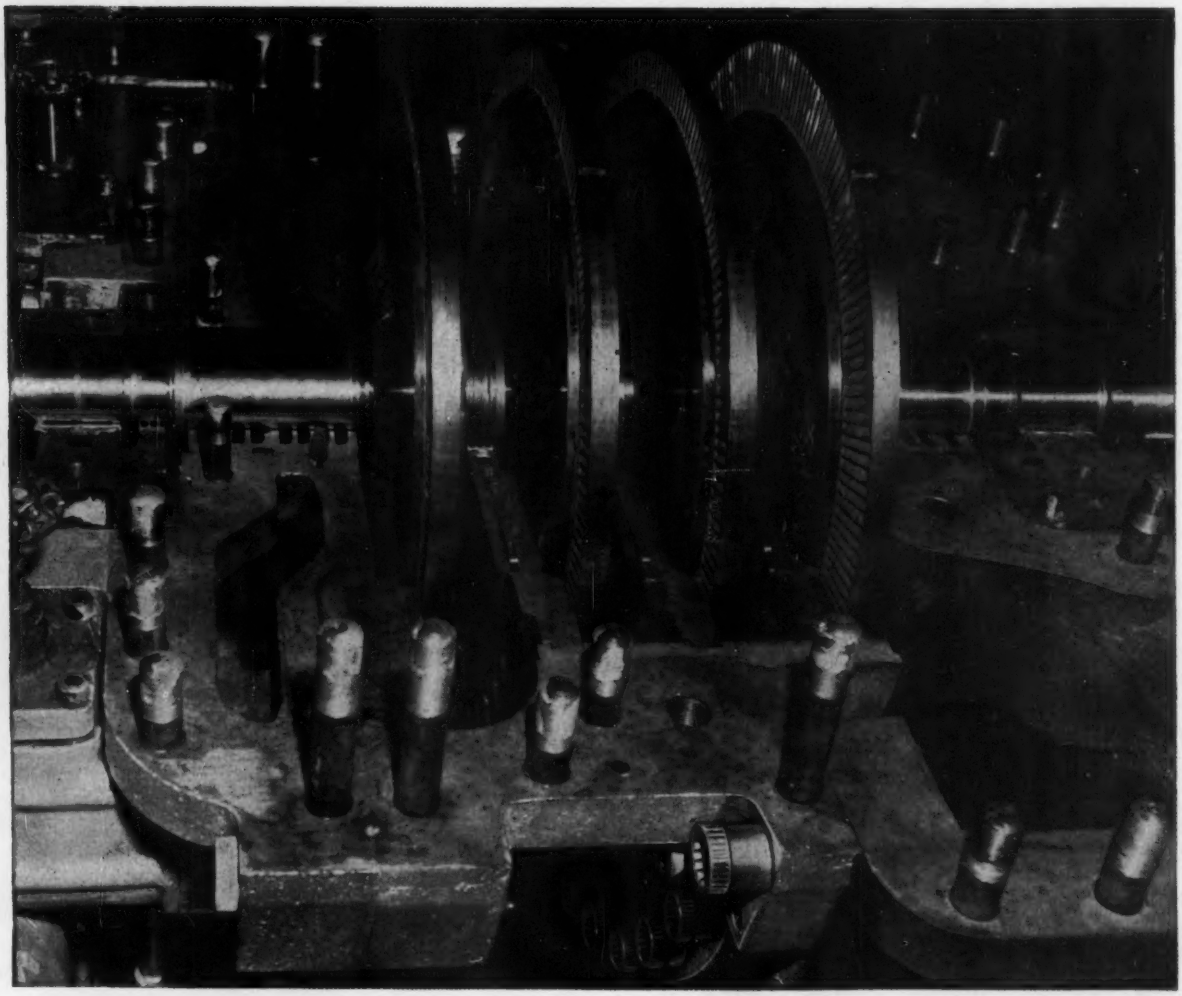
Kind of service... Valves are installed in piping where pressurized chlorine (130 psi) is mixed with caustic to produce sodium hypochlorite. System is occasionally open to atmosphere and entrance of moist air creates a corrosive condition.

The pay-off... *Valves in good condition after two years service.*

Do you feel that some of your equipment in corrosive service does not have the life it should? If so, high nickel alloys, such as the ones mentioned above, might be the answer to your problem. Inco's Corrosion Engineering Section will be glad to work with you.

*The term "Hastelloy" is a registered trademark of Union Carbide Corporation.

INCO TRADE MARK THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.



THE INSIDE STORY OF A MURRAY HIGH SPEED COMPRESSOR DRIVE TURBINE REVEALS THE REASONS FOR MURRAY'S UNIVERSAL ACCEPTANCE

A look at MURRAY'S rugged construction from the inside shows the husky shaft and heavy accurately formed discs with generous sized hubs designed to withstand the axial and radial stresses imposed by this type of service.

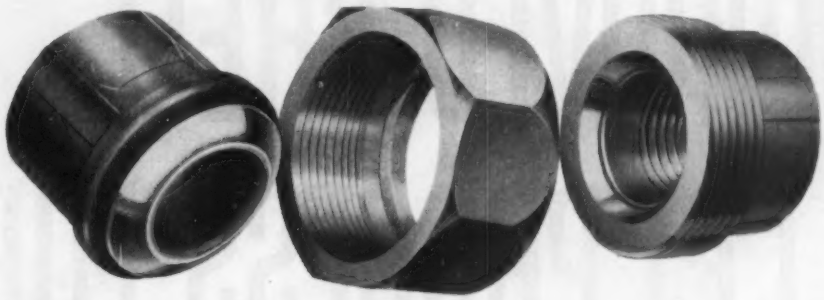
Large-dimension disc rims receive the specially contoured stainless steel blades with the Murray integral shroud. This insures smooth steam passages with maximum strength.

Short bearing spans insure smooth operation and eliminate the hazard of operating in critical speeds.

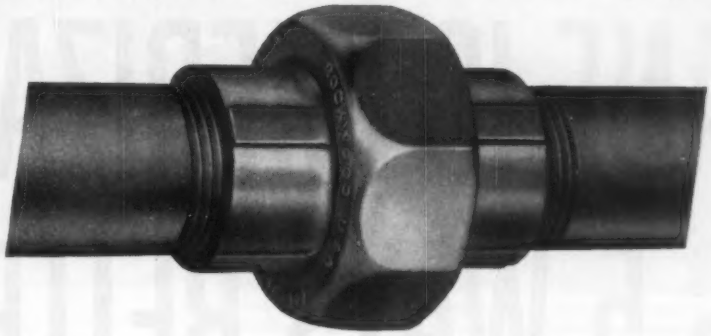
A look at the heavy flanges and husky bolting in the actual unretouched shop photo shown above bears out the extreme ruggedness that typifies every feature of Murray construction.

Our nearest representative will gladly help you solve your high speed compressor drive turbine requirements. Just write to Murray Iron Works Company, Burlington, Iowa for his name.

★ ★ **Murray Turbines** ★ ★



Because the male seat
is 150 Brinell harder than .....the female seat.....



Rockwood unions will not gall when making up!

HARDNESS DIFFERENTIAL

makes the big difference. This exclusive Rockwood feature means this #603 union will perform better and last longer . . . making a really trouble-free joint.

COMPLETE INTERCHANGEABILITY — Even under difficult working conditions, Rockwood Union #603 gives you superior performance. And each part of the #603 is interchangeable.

EXCLUSIVE "ROCKWOODIZING" — There's another big difference that pays off, too! That's exclusive "Rockwoodizing" process that protects the entire Union including threads, against corrosion. Add these big advantages to the fact that both seats are made of corrosion-resistant AISI molychrome steel, forged in place and bonded-locked under 100,000 and 400,000 pound pressure and you'll know why you can't buy a better Union.

ROCKWOOD SPRINKLER COMPANY

Distributors in all principal industrial areas

GET ALL THE FACTS on the Rockwood Union #603, mail coupon now.

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
2403 Harlow Street
Worcester 5, Mass.

Please send me prices and further data on the new Rockwood Union #603. I would also like the name of the nearest Rockwood distributor.

Name.....

Title.....

Company.....

City.....Zone..State.....

For more data on advertised products, use Readers' Service Cards, last page.

IMPROVED SHELL LPI PROCESS FOR BUTANE ISOMERIZATION IS 5 WAYS BETTER

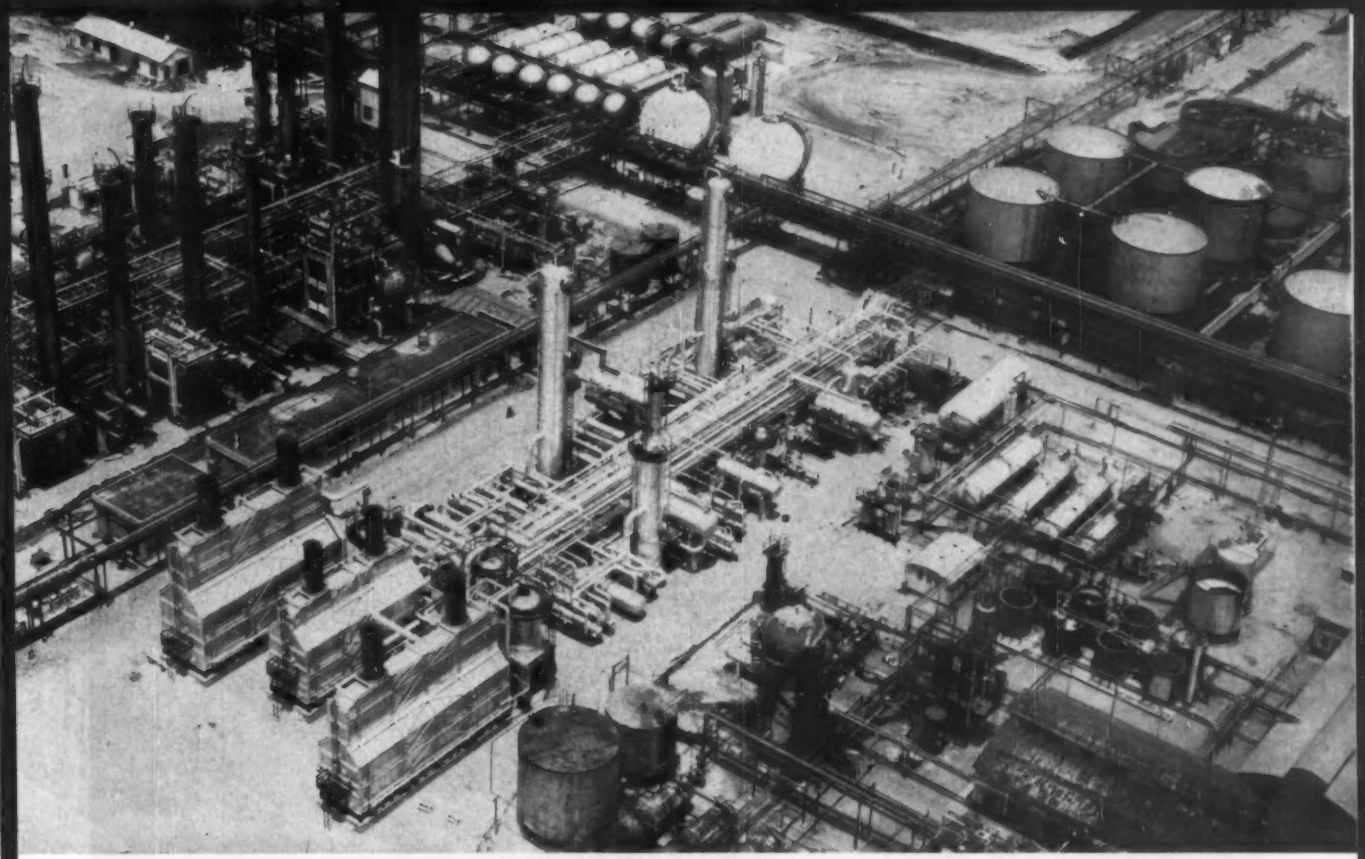
Shell's Liquid Phase Isomerization
makes it more economical than ever to
convert n-butane to isobutane

NEW PROCESS SCHEME MEANS:

1. highest conversion of any known process
2. lower process plant cost
3. high flexibility—with minor addition can isomerize n-pentane
4. high stream factor
5. lower cost of isomerizate fractionation

For technical details and cost estimate, see your engineering contractor. LPI process is licensed by Shell Development Company, 50 West 50th Street, New York 20, New York.

SHELL DEVELOPMENT COMPANY



Wilshire Oil Company of California's new catalytic reforming and desulfurizing units at Norwalk, designed and constructed by SWECO to produce high-octane motor fuel.

Teamed to Upgrade Lowgrade

Working together, Wilshire Oil Co. of California and SWECO have been solving process problems since 1923. They've done it again with this new 10,000 BPD Platformer-Unifiner for premium-quality gasoline.

To help satisfy the growing thirst of modern auto engines for higher octane fuels, Wilshire Oil Co. of California decided to add a new catalytic reforming unit at its Norwalk plant. Design and construction were placed in the hands of SWECO's Engineering and Construction Division. A logical choice. The two companies have been working together since 1923, when SWECO built an absorption plant for Wilshire at Santa Fe Springs. And for 34 years, SWECO had been supplying Wilshire with heat exchangers and other process equipment. SWECO was a known *dependable* quantity.

High temperature, high pressure

The Norwalk project was a 10,000 BPD Platformer-Unifiner to upgrade low-octane naphthas. Temperature and pressure requirements were high: The Platformer – using platinum as a catalyst to reform the molecular structure of hydrocarbons–required 975°F., 650 psig. The Unifiner – freeing sulfur from the naphtha to permit high-severity reforming – required 675°F., 850 psig. To meet process requirements, SWECO supplied 13 heat exchangers, designed and manufactured at its Los Angeles plant.

Signed, sealed and "on stream"

Approximately 13 months after SWECO engineers went to work, the Norwalk unit went "on stream." (Total elapsed time included 7 months of field construction.) It's a typical SWECO job. Done right, and done right on time, whether it's in Tanganyika, the Andes, or around the corner in Norwalk, California.

Typical also of SWECO teamwork on all jobs . . . in *engineering and construction* of refineries, chemical plants and ore beneficiating mills . . . in the design and manufacture of *process equipment* . . . in a complete line of *vibrating screen separators* . . . or *extended service* in plant modernization; procurement and expediting; plant operation.

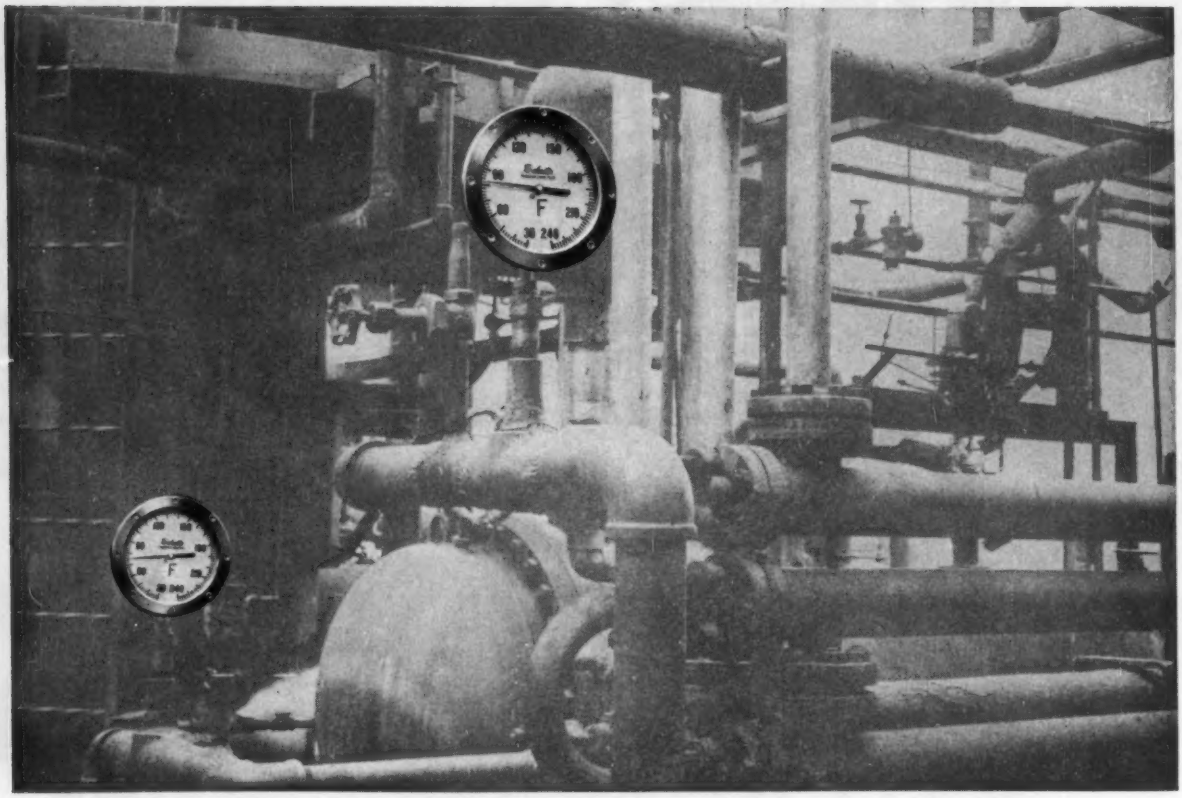
For more information on how SWECO teamwork may help your engineering and construction needs, write for Brochure E-5-333.

SWECO

Southwestern Engineering Company

4800 Santa Fe Avenue, Los Angeles 58, California

Engineers and Constructors . . . Manufacturers



There's an RMC thermometer for almost every industrial requirement

Dial sizes from 1″ to 5″, stem lengths from 2½″ to 70″, scale ranges from −150° F to +1000° F. These figures represent *only* Rochester Manufacturing Company's *standard* thermometer specification limits. There is practically no limit to what RMC can do in the way of *special* thermometer applications.

Standard or special, *all* RMC thermometers are made of corrosive-resistant stainless steel, have hermetically sealed non-fogging dial chambers, are available with RMC's exclusive external recalibration device, and are guaranteed accurate to 1% of scale range. Why not remove temperature indication problems from your unsolved list—turn them over to RMC.

Look to RMC for Full-Line Instrumentation — for manufacturers and users of processing equipment—and many consumer products.

DIAL THERMOMETERS

PRESSURE SWITCHES

PRESSURE GAUGES

LIQUID LEVEL GAUGES

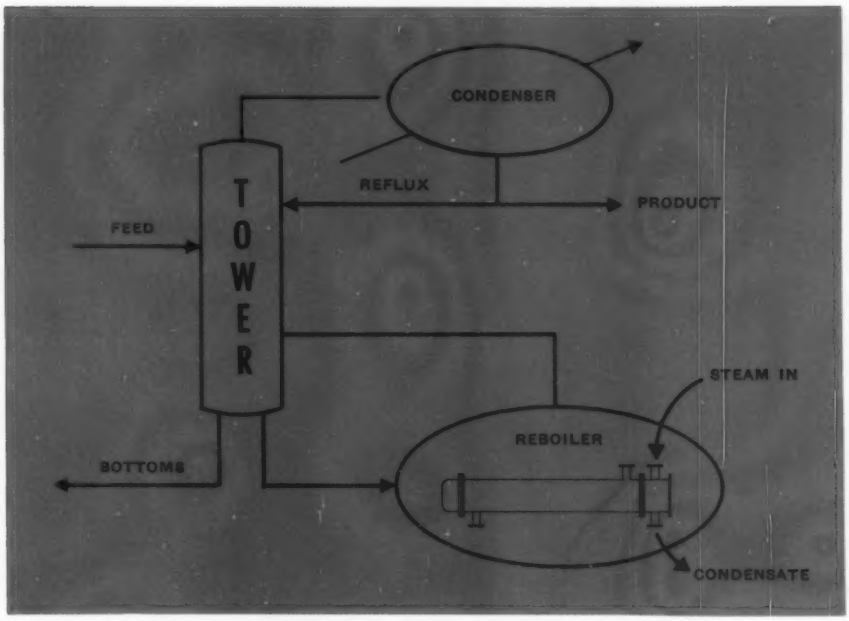
REPRESENTATIVES IN ALL PRINCIPAL CITIES

Tell us your requirements for direct mounting and remote indicating instruments, and let RMC Engineering skill provide the answers!

RMC

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

ROCHESTER MANUFACTURING CO., INC. • 38 Rockwood Street, Rochester 10, N. Y.



WOLVERINE TRUFIN® DOES IT AGAIN

REDUCED TUBE CLEANING FREQUENCY BOOSTS BUTANE REBOILER EFFICIENCY

BY ERNEST DODD

Because of their enthusiasm, Texans undergo a great deal of teasing. But there's one thing that's sure. Show a Texan a product that can help him do a better job and he'll put it to work—*but fast.*

Such a product is Wolverine Trufin Type S/T—the integrally finned condenser tube. Here is the story of how process engineers in a certain Texas refinery are using this extended surface tubing to increase butane reboiler efficiency.

Slightly more than a year ago, these engineers placed on stream, a reboiler with steam on the tube side and butane, containing a fairly large amount of pentanes, on the shell side. The unit was tubed with 384 pieces of Trufin Type S/T condenser tube which, because of its increased surface, enabled the refinery to handle the reboiling of this mixture by using steam at atmospheric pressure.

During the first month of operation, overall heat transfer coefficients were taken. However, these coefficients appeared so high for the mixture involved, that the engineers stopped taking data and decided to see what the overall operation would be over a longer period of time.

From previous experience, the engineers knew that when the unit was tubed with plain tube it was necessary, after approximately a year, to increase steam pressure by 75 or 80 pounds to accommodate the heat load. However, as the months rolled by, the reboiler continued to operate at atmospheric pressure. Furthermore, it had always been necessary, after a year of operation, to pull the plain tube bundle for cleaning.

The Trufin-tubed unit showed no indication of requiring cleaning. Indeed quite the contrary is true, the interpretation of their own data has convinced the engineers that it will not be necessary to clean the shell side of this unit for an indefinite period.

Since the object of retubing with integrally finned tubing was to increase on stream time, the conclusion of these processing engineers is that Wolverine Trufin Type S/T has amply proved its ability to withstand fouling in this type of operation for longer periods than does prime surface tubing.

TYPE S/T AT HOME IN OLD OR NEW UNITS

Wolverine Trufin Type S/T is a completely versatile condenser tube—equally at home, in new units or old. When new heat exchangers and condensers are designed around Wolverine Trufin Type S/T, they are smaller and more compact because Trufin's integral fins increase heat transfer surface—extract more BTU's per foot of tube. The result is a substantial saving in direct tube costs as well as in labor and the materials that go into headers, baffles and shells.

When used for retubing purposes, Type S/T steps up the capacity of existing equipment because its greater surface area packs more heat transfer surface into the same size shell.

Also of major importance when retubing, is the fact that Trufin Type S/T is completely interchangeable with the plain tube it is designed to replace. During the finning process the ends of the tube are left without fins and the tube is designed so that the O. D. of the plain end is slightly larger than the O. D. over the fins.

Because of this, Trufin can thus be inserted into the bundle and rolled directly into the tube sheet in the regular manner using standard retubing techniques and tools.

TECHNICAL HELP FROM FIELD ENGINEERING SERVICE

Always available to help customers solve problems in alloy selection, design and corrosion, etc., are the skilled members of Wolverine's Field Engineering Service. Their services are yours without obligation. Call on them next time you need help.

SEND FOR THIS FREE BOOK

Wolverine's condenser tube catalog is a ready source of information for those engaged in the field of heat transfer. In addition to descriptions of Wolverine's complete condenser tube lineup this valuable book also has sections on alloys, specific tubing applications, the effects of corrosion on various metals, etc. This handy reference book is yours absolutely free. Write for your copy

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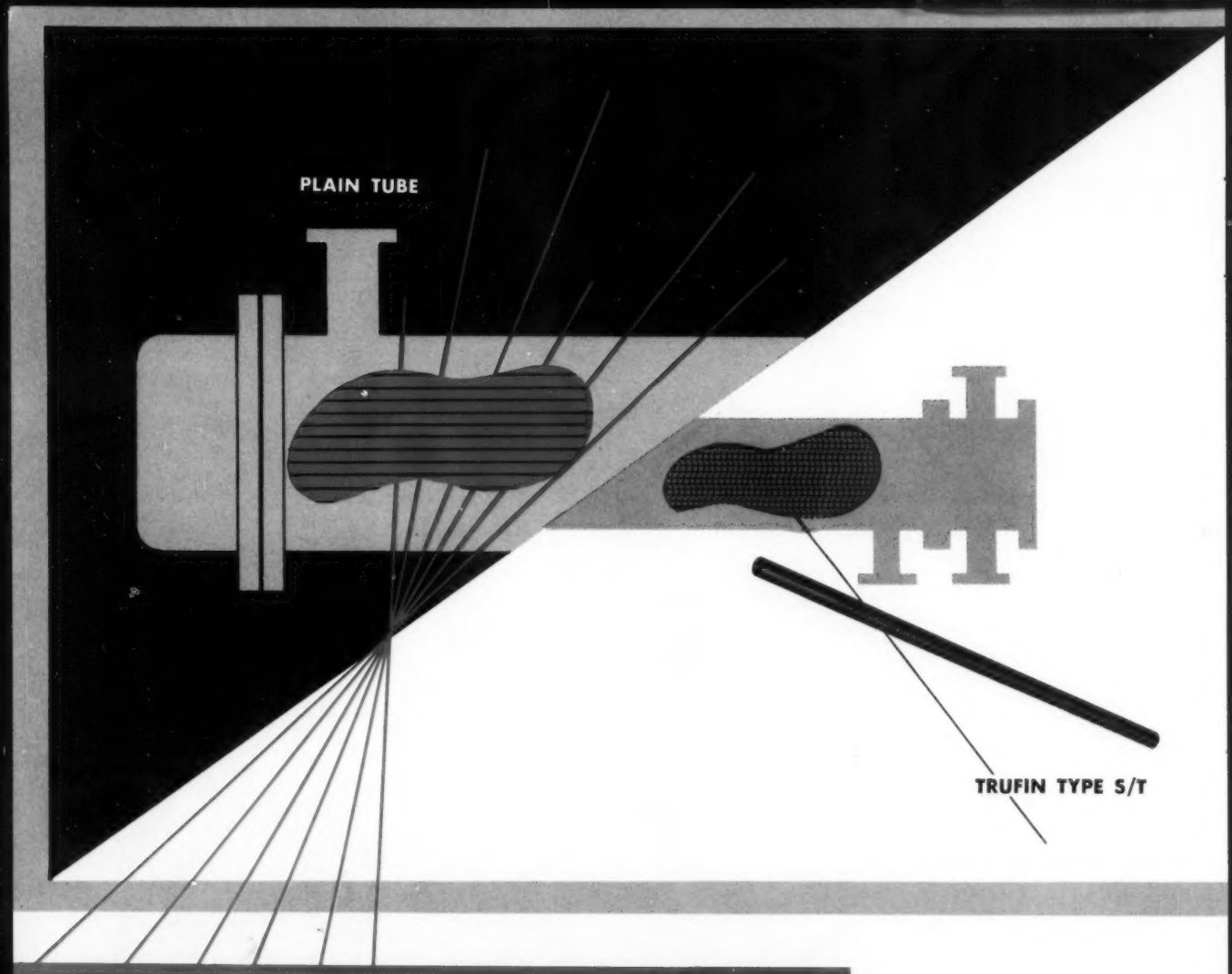

DON'T DESIGN IN THE DARK

With the development of Wolverine Trufin Type S/T —the integrally finned condenser tube—a new day has dawned for designers and fabricators of heat transfer equipment.

Now it is possible for engineers to design lower cost heat exchangers. All that is necessary is to design around integrally finned Trufin Type S/T—rather than around plain tube. Trufin, you see, has integral fins which are actually squeezed from the tube wall. The result is more heat transfer surface per foot of tube which, of course, means greater BTU extraction.

Because of its integral fins Trufin Type S/T, for example, actually has more than 2½ times as much surface area as a piece of prime surface tube of comparable diameter and length. *This is equivalent to an overall increase in surface area of 150%.*

If you are designing new equipment—or retubing old —why not let Wolverine Trufin Type S/T help you shed new light on your problems. For more detailed information write for your copy of the Trufin Catalog.

Wolverine Trufin is available in Canada through the Unifin Tube Co., London, Ontario.

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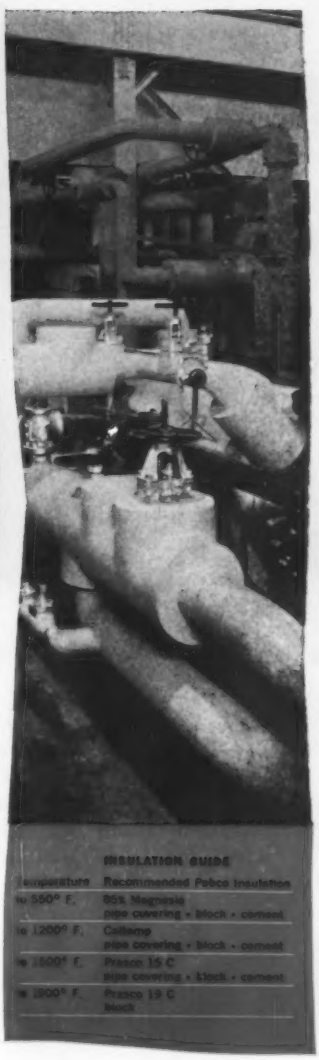

Name your temperature. A performance-proved Pabco pipe or block insulation will maintain it at economical levels up to 1900° F. With Pabco Caltemp, 85% Magnesia, or Prasco Insulations, heat losses are reduced to an absolute minimum . . . finest performance assured. For data on technical advantages, case histories, or engineering consultation . . . write . . . or contact one of Pabco's insulation engineers.

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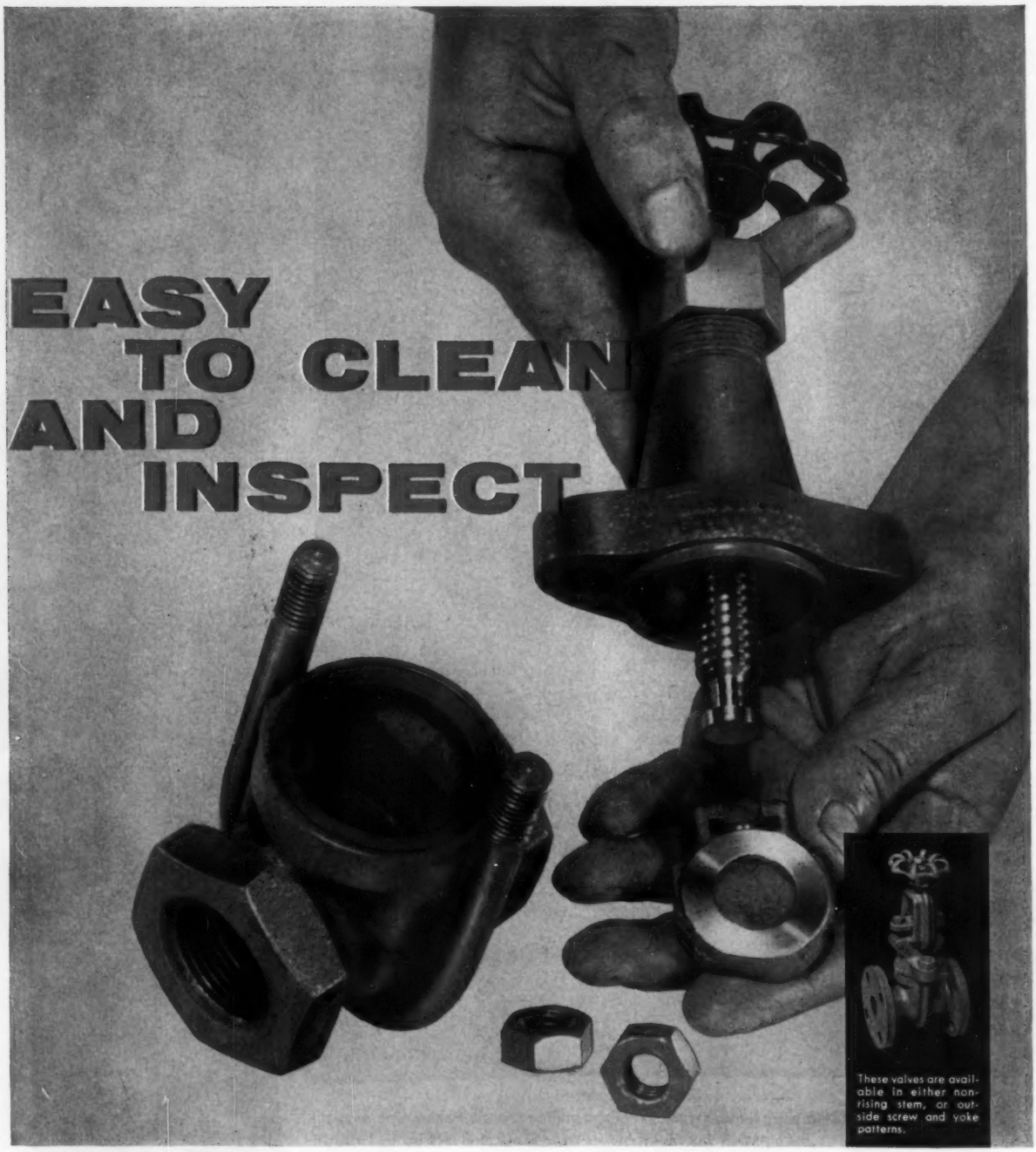
INSULATION GUIDE	
Temperature	Recommended Pabco Insulation
to 550° F.	85% Magnesia pipe covering • block • cement
to 1200° F.	Caltemp pipe covering • block • cement
to 1600° F.	Prasco 15 C pipe covering • block • cement
to 1900° F.	Prasco 19 C block

For more data on advertised products, use Readers' Service Cards, last page.



Walworth iron body saddle type wedge gate valves are suitable for use on steam, water, gas, gasoline, oil, and many process lines. They are easy to take apart, simple to service, fast to reassemble. Walworth saddle-type valves are available in a wide range of sizes in eleven different combinations of design and materials including bronze-mounted, all-iron, and ni-resist; with both flanged and screwed ends. All types can be repacked under pressure when fully opened or fully closed.

Ask your local Walworth distributor to give you complete information or, write for circular.

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Direct... **FACTORY-TO-YOU**

COLD-DRAWN SEAMLESS

STEEL TUBING

COLD FINISHED BARS

Direct from the largest tube mill in the West means you save time and you get what you specify. Pacific can provide seamless tubes in carbon, alloy and stainless steel, and electric resistance welded tubing in sizes up to 4 inches in diameter. If you require extra-long tubing, Pacific is equipped to cold draw straight lengths up to 58 feet long. Pacific tubes are "quality controlled" at every critical stage of manufacture to insure close tolerance, workability and long service life.

COLD DRAWN BARS

Precision drawn Patco round bars are quickly available in many analyses from 3/16" through 3½". A wide range of chemistries include C-1018, C-1137, C-1117, C-1045 and MCX-1213, plus Ledloy Grades A & B.

PRECISION SHAFTING

Ground, polished and stress relieved in the Pacific mill, constant laboratory inspection during every vital step insures the highest "quality controlled" product... where precision counts. Available through 2 3/16" diameter.

Avail yourself of Pacific Tubes' Engineering Service in solving your metallurgical or application problems.

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TYPE 12 A TEMPERATURE TRANSMITTER
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ADJUSTED RANGE
15 PSI =
3 PSI =
THE FOXBORO COMPANY
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Type 12A pneumatic

Temperature Transmitter Improves Remote Control

. fast — sensitive — rugged!

There is no easier, simpler way to measure remote temperatures, over so wide a range, with such high sustained accuracy and speed, and at so low a cost!

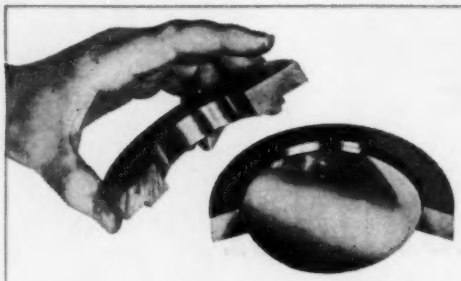
The Type 12A Temperature Transmitter converts temperature measurement to a linear air output signal, which is transmitted to any standard 3-15 psi recorder or controller. Measuring spans of 50, 100, 200, or 400 degrees F. are available, set as required within the over-all transmitter range of —100°F (lower when necessary) to +1000°F. Fully compensated for ambient temperatures and pressure, this rugged, highly responsive instrument performs outstandingly under the most severe conditions. And it's insensitive to mechanical vibration.

The transmitter weighs only 7 pounds with its integral mounting bracket. It can be mounted anywhere . . . in any position . . . even directly on a bulb well! The gasketed, weatherproof housing permits installation in any hazardous, corrosive, or outdoor location. Transmission line is conventional air tubing — no troublesome conduit, no costly capillary to run.

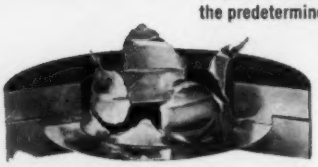
Derivative action is furnished for optimum performance when process or transmission lags exist.

Write for Bulletin 13-17. It explains fully why the Foxboro Type 12A Temperature Transmitter gives better performance with lower installation and maintenance cost. **The Foxboro Company, 748 Neponset Ave., Foxboro, Mass., U.S.A.**

Pneumatic Temperature Transmission



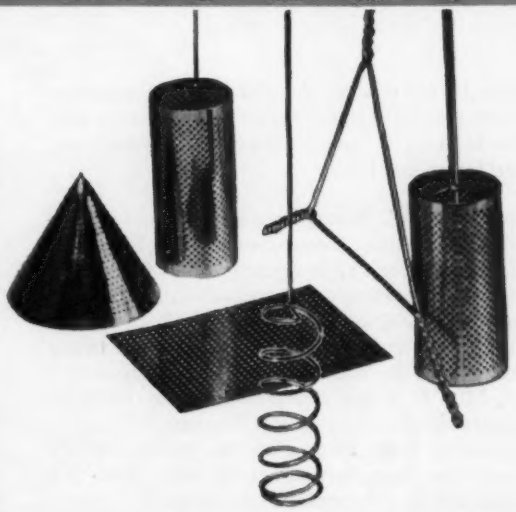
RUPTURE DISCS... discs of precious metals, resistant to most corrosive agents and unattacked under conditions that base metals could not withstand. Specific physical properties ensure bursting only at the predetermined pressure.



DEOXO® PURIFIER... provides low-cost catalytic purification of hydrogen and other gases to the extent of less than one part oxygen per million. Requires no operating expense, no maintenance, no reactivation, no auxiliary heating, no water cooler. Extremely simple installation.

important for petroleum processing...

SUPER-SENSITIVE DEOXO® INDICATOR... for measuring oxygen or hydrogen present as impurities in other gases. Accurately indicates from 0.0002% to 0.0200% (2 to 200 parts per million) oxygen, and from 0.0004% to 0.0400% hydrogen. A dual range permits measurement of up to 0.25% oxygen or 0.5% hydrogen.



LABORATORY WARE... a wide variety of forms and sizes for chemical and physical purposes, made of platinum or any desired alloy. Line includes crucibles, reshapers, triangles, dishes, electrodes, anodes and cathodes.

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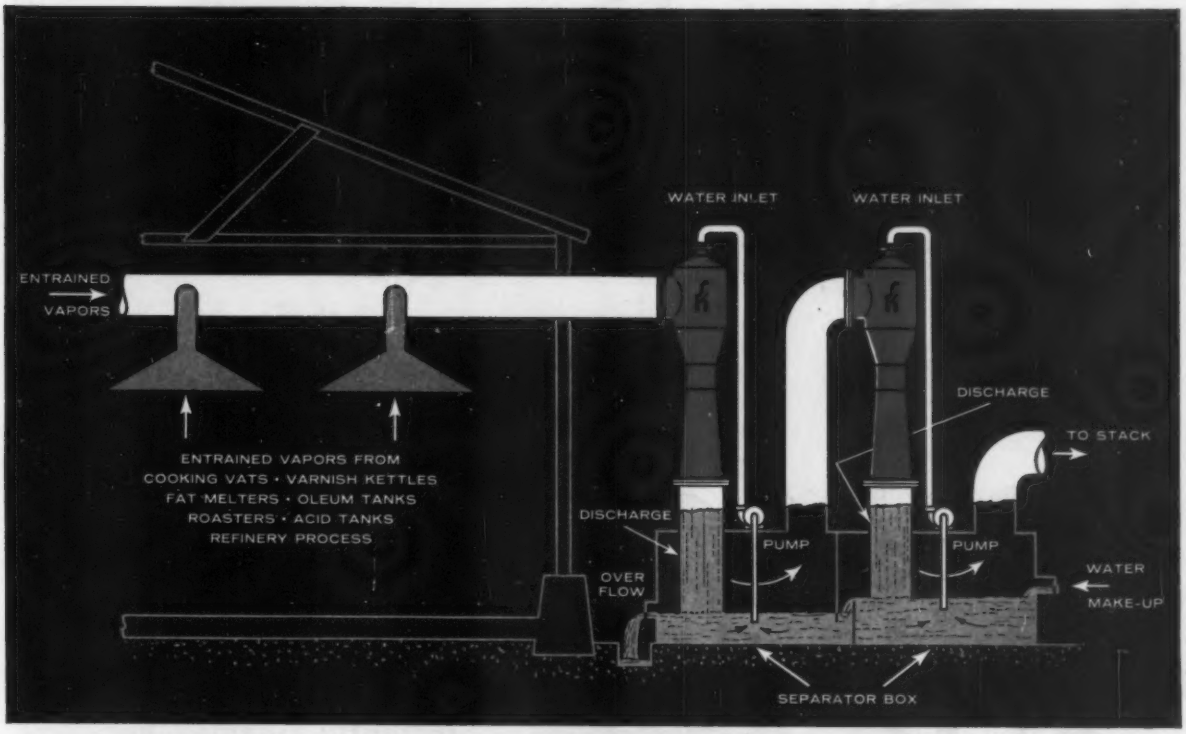
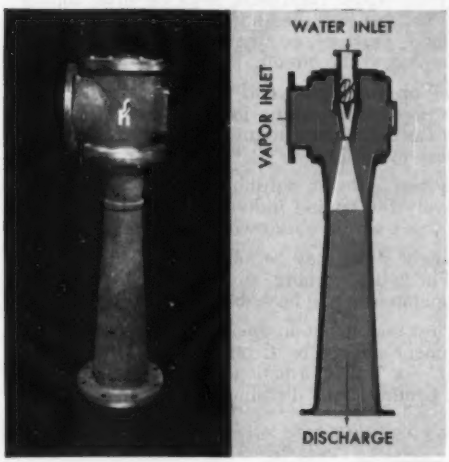


CONTROL OBJECTIONABLE FUMES, GASES, VAPORS

with an economical SK Fume Scrubber

Photo and sectional drawing of an SK Fig. 4010 Fume Scrubber



A food plant in California uses an SK Fume Scrubber to condense steam and scrub oil vapors from cooking vats. A large chemical manufacturing plant on the eastern seaboard uses a battery of SK Fume Scrubbers to condense steam and purge entrained gas containing H_2SO_4, SO_2, H_2S, TiO_2, and ore dust. A mid-western manufacturer uses SK Fume Scrubbers to vent oleum tanks. A soap maker in Pennsylvania uses a scrubber to remove ammonia fumes from a plant building and cool the building at the same time.

From coast to coast, chemical and food processing plants, refineries, paint and varnish manufacturers, fertilizer, and other manufacturing plants are using SK Fume Scrubbers to control objectionable—sometimes dangerous—fumes, gases, vapors, and dusts.

These manufacturers have found that SK Fume Scrubbers are reasonably low in initial cost, require little maintenance, and are an effective means for conforming to local ordinances which prohibit the pollution of air.

Made in a wide range of sizes from cast iron, steel plate, Haveg, stoneware, or other materials or with linings of rubber or Polyvinyl Chloride, or other synthetic materials, SK Fume Scrubbers can help you solve a fume or dust problem. Why not get the whole story. Send for Bulletin 4R which contains complete information on SK Fume Scrubbers.

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ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin 10-RA.
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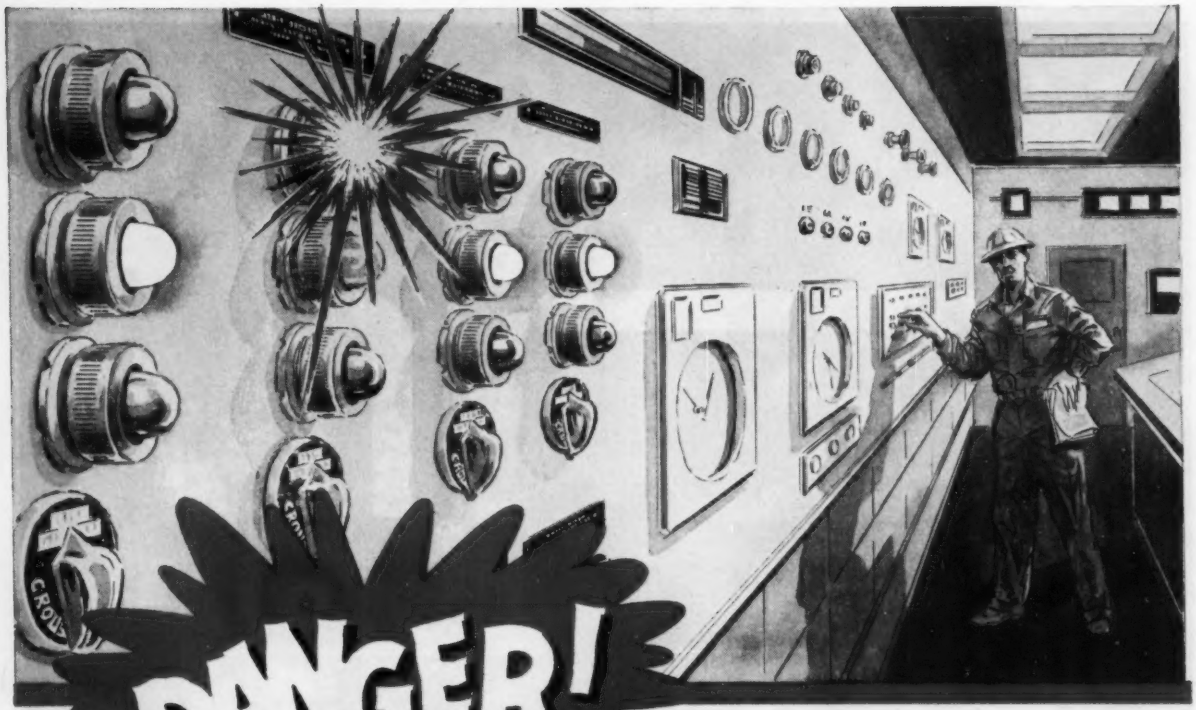

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. . . instantly signaled by Crouse-Hinds *Visularms*®

*Dust-ignition-proof.

In oil refineries, chemical plants, synthetic rubber plants — wherever constant watch of processing is necessary — Crouse-Hinds Condulet® *Visularms* provide visual indication of process conditions, and instant control of manufacturing equipment.

By means of pilot lights (and bell, horn or siren signals where desired) *Visularm* indicates normal or abnormal temperature, liquid level, pressure, or other conditions which can be electrically coupled to the circuit.

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A Visularm system delivers substantial savings by eliminating the necessity for buying individual components . . . housing them . . . and wiring your own system completely.

Two- or three-light styles may be mounted either vertically or horizontally. For audio warning, any number of *Visularms* may be used to operate a single horn, bell or siren.

Visularms are just one of hundreds of items in process control board equipment offered by Crouse-Hinds. Only a few are shown at left. For full information on the complete line, call your nearest Crouse-Hinds distributor, or write . . .

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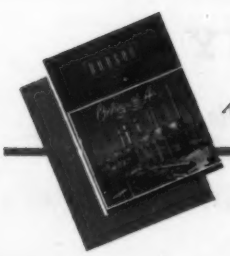
Cooling with Air AND MINIMUM WATER IN A MODERN REFINERY

Process cooling in Cosden Petroleum Corporation's new West Texas refining units is largely by direct use of air. Over 250 million BTU's per hour are dissipated directly to five billion standard cubic feet per day of air moved by 38 fans in HUDSON Solo-aire or Combin-aire units.

Solo-aire units are used where low effluent temperatures are unnecessary. Combin-aire units, in which air is first precooled with water, are used where lower effluent stream temperatures are required. The cooled water from the Combin-aires is available for other cooling services; the Combin-aires in this case performing the further function of water cooling towers. Water spray, carryover or condensation is impossible as the effluent hot air is under saturated with water vapor. Combin-aires are installed adjacent to other process equipment.

These Solo-aires and Combin-aires at Cosden, and hundreds of other HUDSON units in oil, gas and chemical processing plants confirm the advantages of cooling with maximum air and minimum water.

Before finalizing design of new process units, let HUDSON assist you in determining optimum balance in use of air and water.



Air-cooled equipment bulletin mailed upon request

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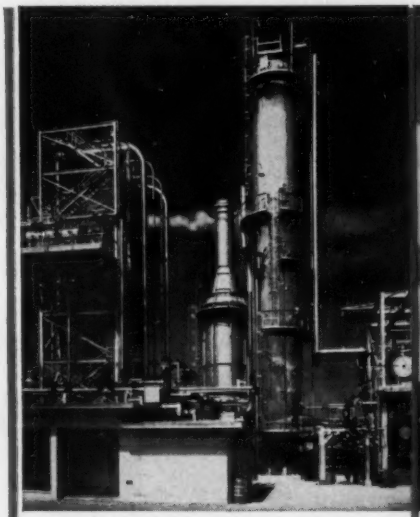
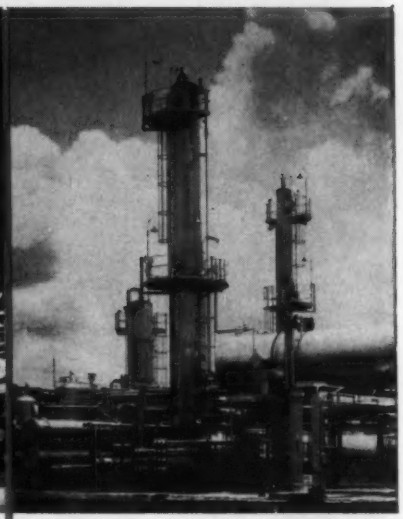
Backed by extensive engineering and construction experience in all phases of the petroleum industry, Blaw-Knox provides an integrated program for projects of varying size and scope.

Design and development facilities include: Plant site surveys • Process engineering • Equipment procurement • Cost control reports • Complete construction • Initial operation

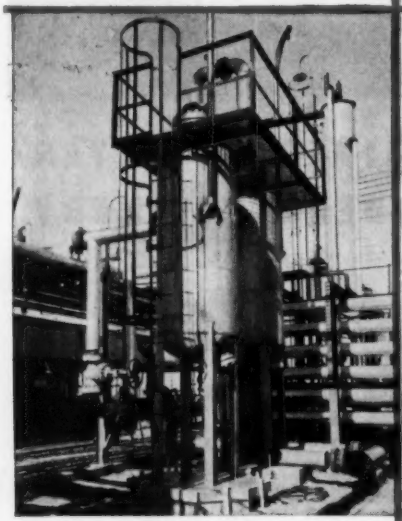
We shall be glad to explore any processing problem, new plant plans or modernization program that you are considering.



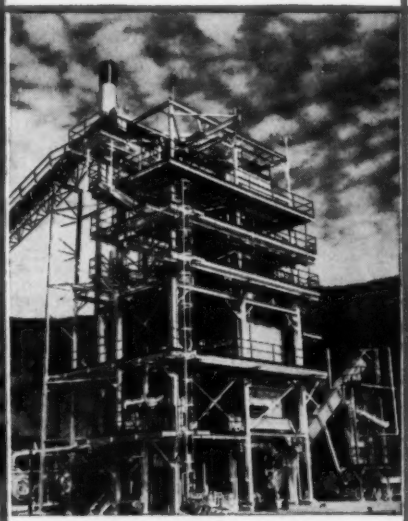
Decarbonizing unit, an exclusive Blaw-Knox development for increasing coking efficiency, lowering costs and improving basic processing procedures.



Alkylation—using sulfuric acid or hydrofluoric acid is one of the many modern intermediate processes supplied by Blaw-Knox.



The world's first Unifining unit, built by Blaw-Knox, improves distillate feed stocks and boosts quality in the product finishing segment of the industry.



This shale retorting plant demonstrates Blaw-Knox leadership in developing future oil sources as well as improving today's processing techniques.

For more information, send for Bulletin 2547, "Petroleum Processing Plants." It describes Blaw-Knox services and reviews results achieved for the industry.

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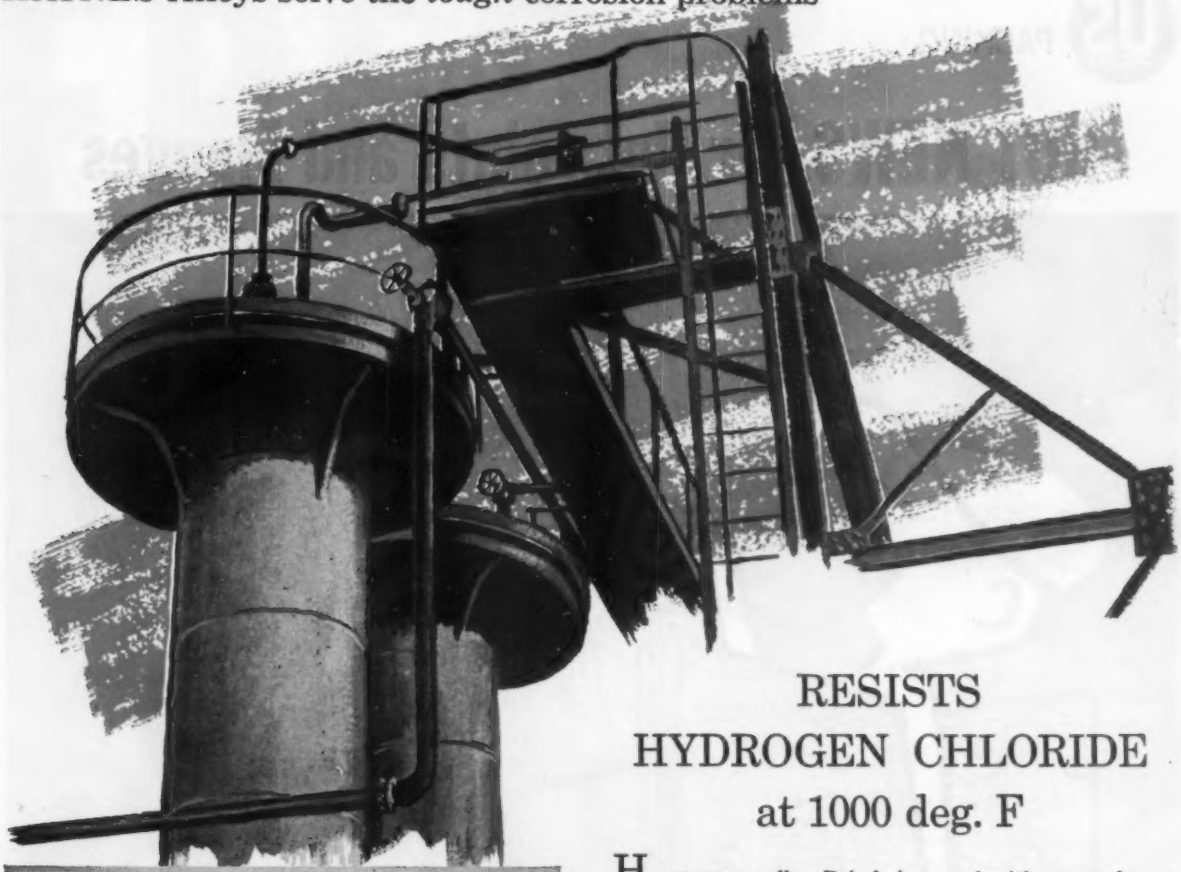
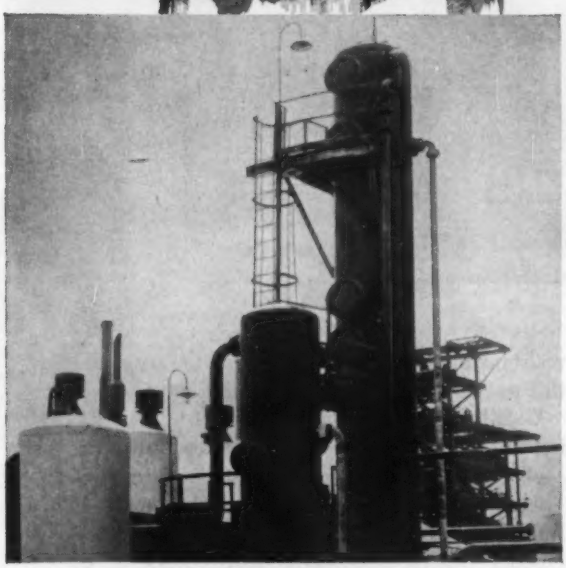
HAYNES Alloys solve the *tough* corrosion problems



RESISTS HYDROGEN CHLORIDE at 1000 deg. F

HASTELLOY alloy B is being used with unusual success in equipment exposed to hot hydrogen chloride gas containing water. In one installation, where the highly reactive gas is at 1000 deg. F., alloy B has outlasted previously used materials by 30 to 40 times! Here, tower covers, piping, and valves made of alloy B are located on top of chlorine burners in a tetraethyl lead plant. They were in service for 6 years before requiring maintenance.

Hydrogen chloride gas is only one of thousands of corrosives that are successfully handled by HASTELLOY alloys. These nickel-base materials have unusual resistance to the hot mineral acids, strongly oxidizing salts, and powerful gaseous oxidants. For complete information, send for the newly published booklet describing these alloys. Write to Haynes Stellite Company, Distribution Section, 30-20 Thomson Avenue, Long Island City, N. Y.



Concentrated Sulphuric Acid flows across perforated trays made of HASTELLOY alloy B in these drying towers. Alloy B resists the corrosive effect of the acid and helps maintain the efficiency of the tower. The trays have been in use since 1949.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

Kokomo, Indiana

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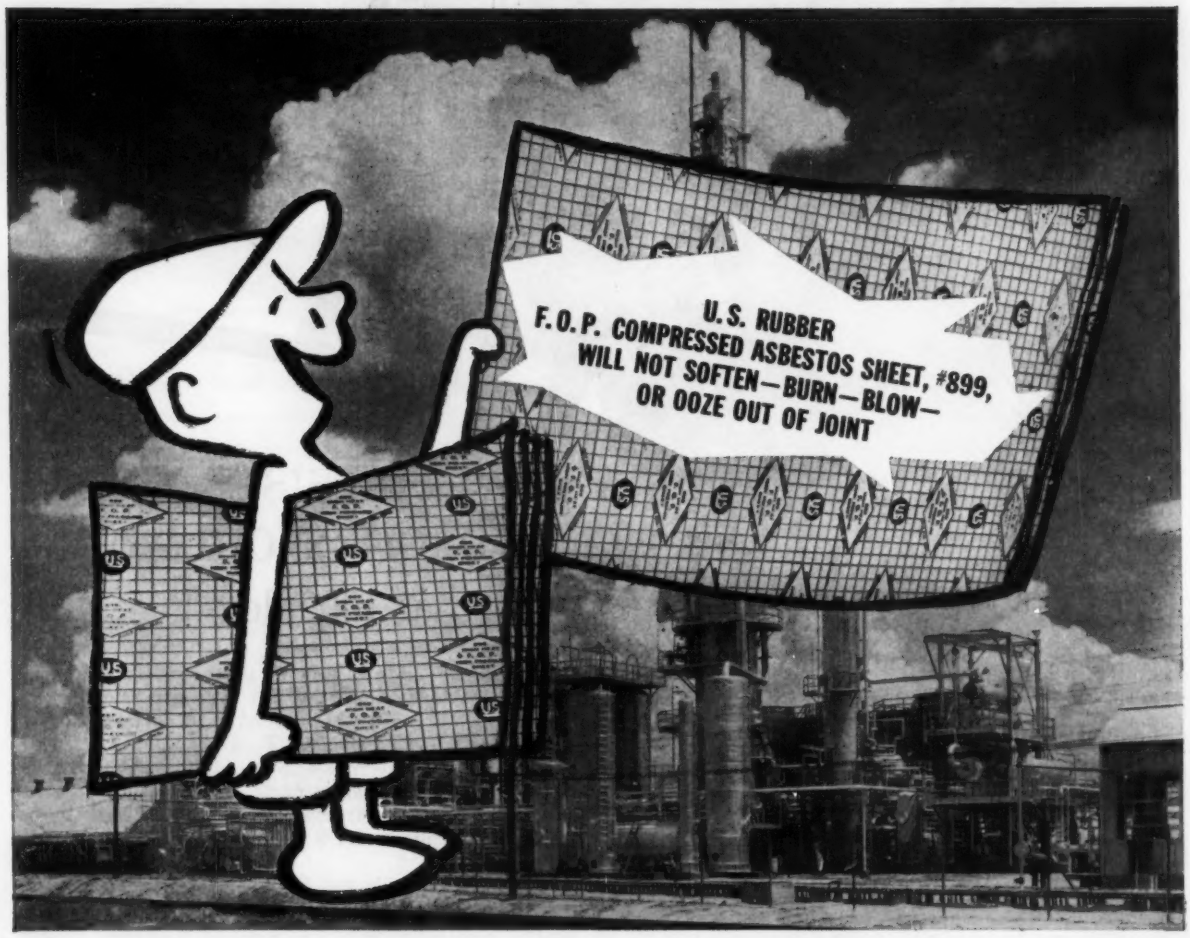
"Haynes," "Hastelloy" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

US RUBBER PACKING

HOT NEWS for Hot Joints and Flanges



This is the packing that's making headlines where the going's the hottest... where flanges or joints must be packed against superheated or saturated steam, air, water, ammonia, gases, oil, gasoline and many chemicals.

U. S. Compressed Asbestos Sheet Packing was the first of its type developed particularly for refineries and chemical plants. It is made by a special process from selected long-fibre asbestos and bonded with exacting combinations of heat-resistant materials. Balanced construction makes this packing ideal for use as Still Head Gaskets.

U. S. Rubber Compressed Asbestos Sheet Packing can be furnished in a variety of constructions, each specially suited to a specific requirement. They are some of the hundreds of styles of U. S. Rubber Packing available at any of the 28 "U. S." District Offices, at selected distributors, or by writing us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

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Mechanical Goods Division

United States Rubber

See things you never saw before. Visit U. S. Rubber's new Exhibit Hall, Rockefeller Center, N.Y.

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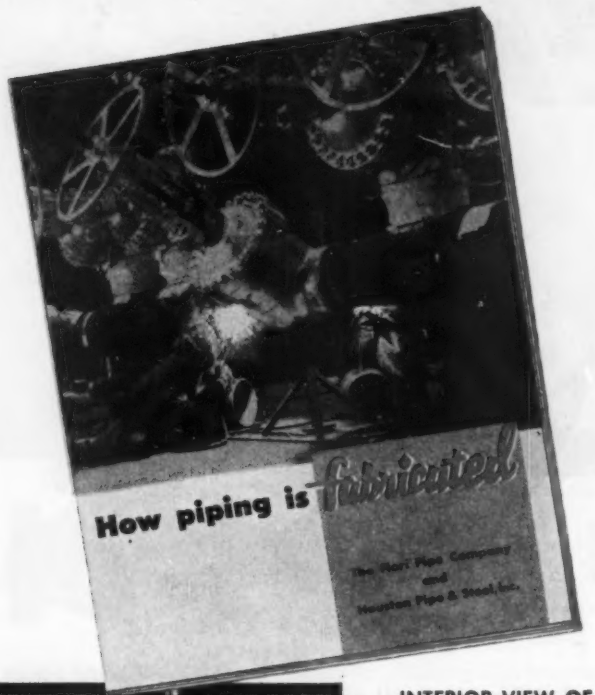
FREE brochure shows NEW PIPE FABRICATING TEAM



THE FLORI PIPE COMPANY and HOUSTON PIPE & STEEL, INC. JOIN FORCES

NEW TEAM ONE OF LARGEST PIPE FABRICATING OPERATIONS IN COUNTRY

Now operating under a single administrative and sales office in St. Louis, the new Flori-Houston team is geared to offer industry a new dimension in pipe fabrication production and service. The addition of the huge Houston Plant to the Flori facilities now offers unlimited production and the combined experience and know-how of all Flori-Houston personnel insures industry a continued high quality product.

INTERIOR VIEW OF HUGE HOUSTON PLANT

...unobstructed production facilities of 560 feet by 106 feet! Visual proof how the new Flori-Houston team can guarantee price . . . delivery . . . quality.

FREE BROCHURE
See the Flori-Houston team in operation.

WHAT THIS MEANS TO INDUSTRY...

1. **PRICE** . . . the new Flori-Houston team is production geared on a quality-volume basis to insure only the best piping at the lowest possible cost.
2. **DELIVERY** . . . the new Flori-Houston team with tremendous multi-plant facilities and service alert policies insures on-time delivery.
3. **QUALITY** . . . new Flori-Houston team combines years of technical experience in all phases of pipe fabricating which insures the same high standards of Flori quality familiar to industry since 1932.

MAIL COUPON TODAY FOR YOUR FREE COPY

GENERAL OFFICES

THE FLORI PIPE CO.

601 East Red Bud — St. Louis 15, Mo.

HOUSTON OFFICE

HOUSTON PIPE & STEEL, Inc.

P. O. Box 2, — Houston 1, Texas

Subsidiaries of Sparton Corporation

THE FLORI PIPE COMPANY
601 E. Red Bud, St. Louis 15, Mo.

Gentlemen, please rush free your new brochure "How Piping Is Fabricated," which gives complete information about the new Flori-Houston team.

Name_____

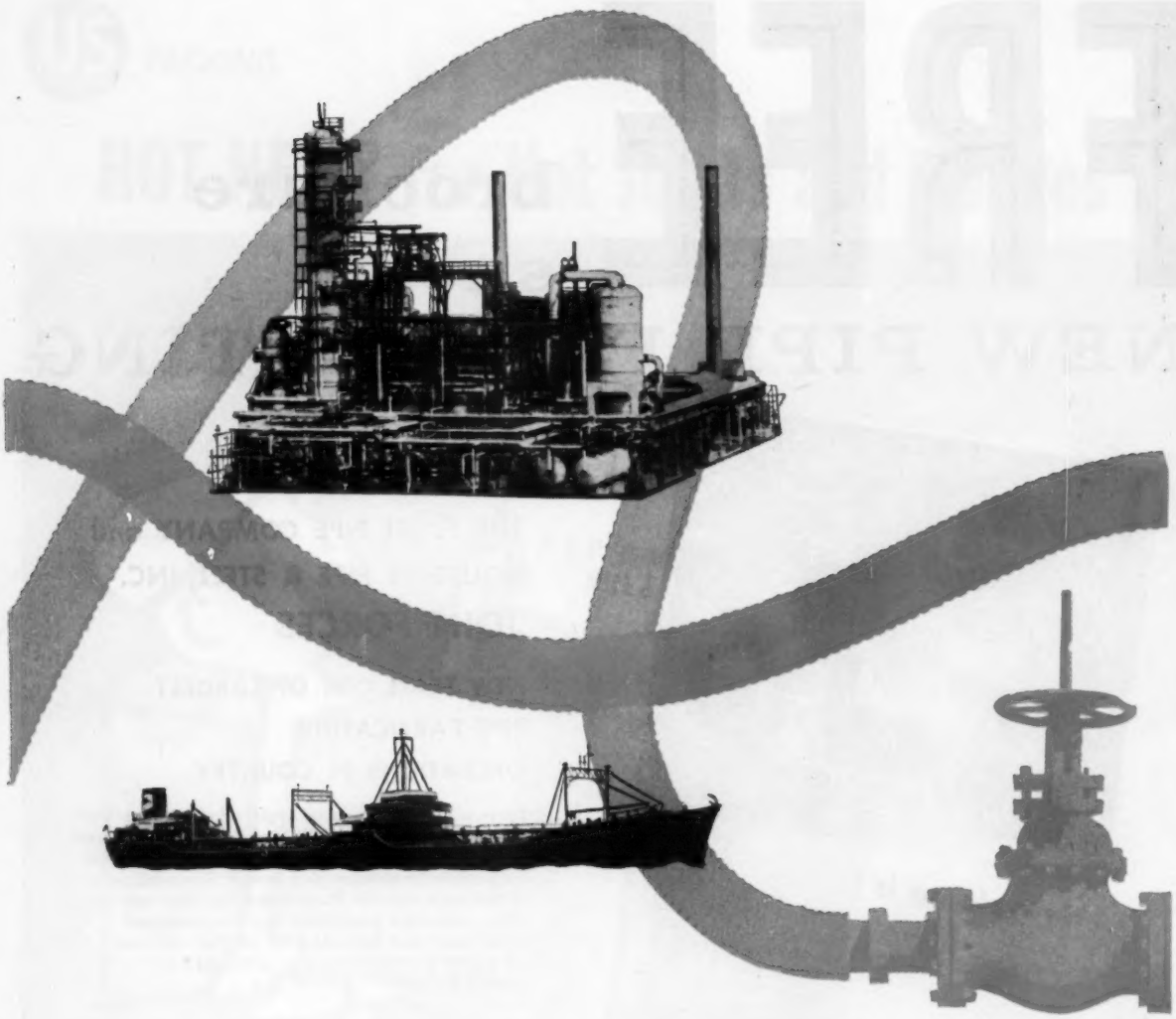
Title or occupation_____

Company_____

Address_____

City_____ Zone____ State_____

PR-57



Sun Ship has furnished equipment for many major oil companies in America

Of essential importance to American welfare is the free, expanding progress of the Oil Industry. Tankers for many of the oil companies have been built in the Sun Ship Yard. Also, refining equipment repairs and replacements have been furnished for the major oil companies.

In addition, Sun builds special machinery and fabricated steel products for a variety of other industries whose problems have been a welcome challenge—readily accepted—easily solved. Call or write our Sales Engineering Department about your plans—or problems. Immediate, courteous attention is assured.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE SINCE 1916 CHESTER, PA.

Austin-Western Hydraulic Crane lowering section of pipe upon a flat bed truck. Superstructure in background is one of the flashing units at Wood River Refinery, Roxana, Ill.

AUSTIN-WESTERN HYDRAULIC CRANE

speeds repairs at Shell's Wood River Refinery

Shell's Wood River Refinery, Roxana, Ill., had six larger cranes, yet in 1955 purchased an Austin-Western for faster handling of 5-ton loads and less.

The company reports: "This crane with its 16-in. tires, four-wheel power steer and four-wheel drive saves time in pulling exchanger tubes and getting around pump houses. With it the men remove heads of heat exchangers, a job that formerly required a large crane, which was more expensive to operate or called for chain blocks which took more men at increasing labor rates. Maintenance men request this hydraulically controlled and maneuverable light crane to lift and transport pumps into the machine shop for repair. It can set a pump right on a boring mill, for instance, without additional handling."

Moves right up to the work. "Being low slung, the A-W goes under the lines in the pipe alleys where larger equipment could not pass. * * * With its 12-ft. extension added to the 18-ft. extensible boom, this crane can remove pump parts through a window section at second story height and later replace them. When a shaft or impeller requires repair in such a location the A-W saves a great deal of hand rigging and consequently many man-hours of time."

Sometimes works around the clock. "Any one of 10 cranemen may be called on to handle the A-W. In the busy season of the year it is sometimes used 7 days a week, right around the clock. * * * It is likely to handle a dozen jobs in 8 hours. * * * New uses for this versatile crane are being [continually] found."

Low cost operation. "The operating cost of this crane is about what other users report for 8 hours' daily use—less than one man's wages."

AUSTIN-WESTERN WORKS
666 Farnsworth Avenue, Aurora, Ill.
Please send complete Gould Certified Report No. 5612.

Name .....
Title .....
Company .....
Street .....
City ..... Zone ..... State .....

Power Graders • Motor Sweepers • Road Rollers • Hydraulic Cranes

BALDWIN BLH LIMA-HAMILTON

AUSTIN-WESTERN WORKS
BALDWIN-LIMA-HAMILTON
Construction Equipment Division
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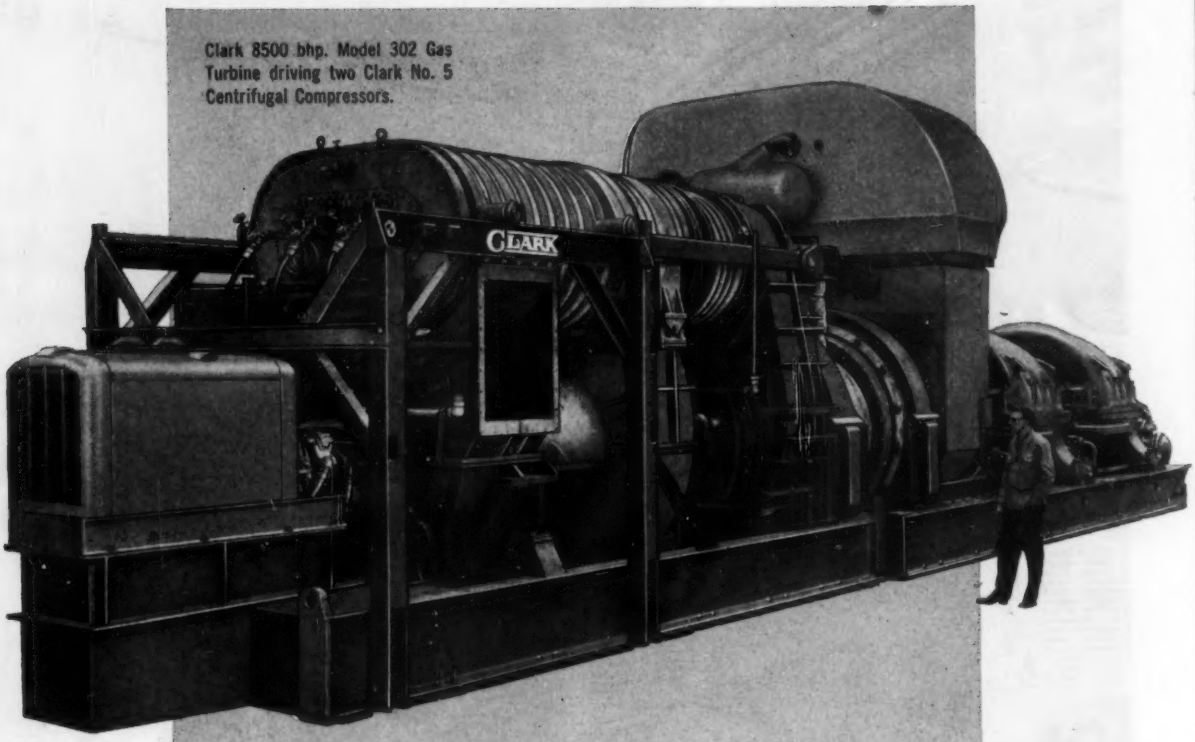
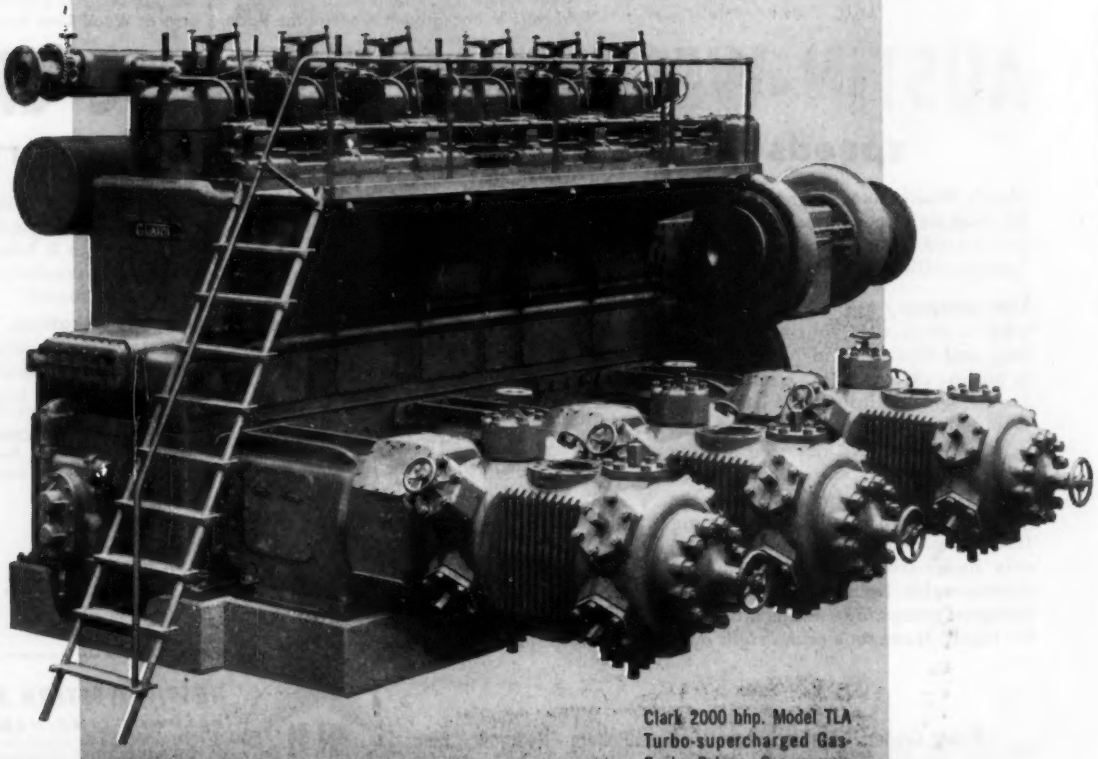


Clark 8500 bhp. Model 302 Gas Turbine driving two Clark No. 5 Centrifugal Compressors.



Clark 2000 bhp. Model TLA Turbo-supercharged Gas-Engine-Driven Compressor.

Gas turbines or engines?

With Clark you eliminate

Prejudice

Gas turbine-driven centrifugal compressors or reciprocating compressors . . . you can get both types from Clark

Prejudice can add substantially to the cost when selecting compressors. At Clark, we build both gas turbine-driven centrifugal compressors and gas-engine-driven reciprocating compressors. In both instances the compressors and drivers are the most modern available.

Our chief concern is to be certain that you obtain the proper unit for your specific installation. This is where our experienced application engineers enter the picture. Both types of units have certain characteristics that may make one or the other best for your particular use. An unbiased opinion, after a careful examination of all the facts and conditions, is vitally important. Clark is the only company that can give you an unbiased opinion because Clark is the only company that builds reciprocating and centrifugal compressors in addition to gas turbines.

Clark application engineers will be pleased to help you determine the right type of compressor and driver combination for your next application.

CLARK BROS. CO., OLEAN, NEW YORK

One of the Dresser Industries

Offices in Principal Cities Throughout the World

CLARK

Centrifugal Compressors
Reciprocating Compressors
Gas Turbines

For more data on advertised products, use Readers' Service Cards, last page.

NEW EMS SERIES
Magnetic,
across-the-line
Motor Starters

INDUSTRIAL CONTROL

PYLETS®

EXPLOSION-PROOF AND DUST-TIGHT

FOR HAZARDOUS LOCATIONS

SECOND TO NONE FOR... SAFETY AND ECONOMY... LONG SERVICE LIFE

New ECB Series Circuit Breakers

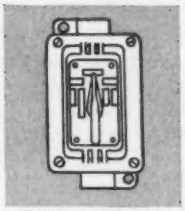
NEW

CORROSION-PROOF COVER JOINT:

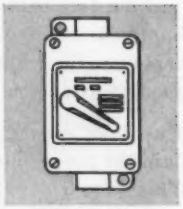
The metal to metal joints of all explosion-proof Pylets, both the ground joint types and the threaded joint types, are cadmium plated to maintain the integrity of the flame arresting path against corrosion. Only cadmium plate can provide this valuable protection on ferrous alloy castings.

The new EMS motor starters, ECM combination motor starters and ECB circuit breakers have cadmium plated, ground cover joints plus the following features:

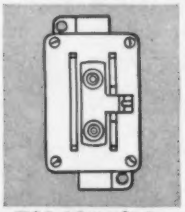
- COMPACT RECTANGULAR SHAPE
- HINGE SUPPORTED COVER
- RAIN-TIGHT PROTECTION
- COMPLETE ACCESSIBILITY FROM FRONT
- MINIMUM BENDING OF CONDUCTORS
- TAPERED TAPPED HUBS



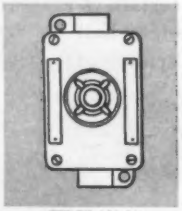
ER-SS Selector Switches



ER-M Manual Motor Starters



ERC Push Button Stations



ERP Pilot Lights

Sold Nationally Through Authorized Distributors. Write for Literature.

THE PYLE-NATIONAL COMPANY

WHERE QUALITY IS TRADITIONAL

North Kostner Avenue, Chicago 51, Illinois

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SINCE 1897

CONDUIT FITTINGS • PLUGS AND RECEPTACLES • LIGHTING FIXTURES • FLOODLIGHTS

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YOU PROBABLY DON'T NEED TO READ THIS AD . . .

WHY? Because, if you are one of the thousands who use Orbit Forged Steel Rising Stem Valves, experience has proved that these valves are built for trouble-free performance — very few ever need to be repaired. Therefore . . .

THIS AD IS DIRECTED TO THE VERY FEW ORBIT VALVE CUSTOMERS WHO HAVE VALVES THAT NEED REPAIR!

On an average less than ½ of 1% of Orbit Valves are returned to the factory for repair. This includes valves damaged by improper handling, installation or maintenance. However, if an Orbit Valve needs reconditioning, we urge the user to take advantage of our exchange valve repair system by returning the valve to the factory.

Facts about Orbit exchange-valve repair system . . .

Under Orbit Valve Company exchange valve repair system and subject to the conditions outlined here, the customer may return any damaged Orbit Forged Steel Rising Stem Valve to our Factory at Tulsa, Oklahoma or to any one of our Branch Warehouses, accompanied by a letter giving return instructions, valve serial Number and source of Purchase Order to be furnished to cover reconditioning service and receive in exchange for the damaged Orbit Valve a valve of the same size and test pressure from our reconditioned stock, for which we charge only 35% of the current cost of a new valve. Customer pays freight both ways.

All damaged valves received by us under the above conditions are subject to factory inspection to determine extent of damage. In those few cases where damage to the valve is extensive and it is estimated that repair charges will exceed 50% of the cost of a new valve, the exchange will not be made on a 35% basis, instead, the customer will be immediately notified by letter containing our recommendations and stating the amount of additional repair charges that will be necessary to return the Orbit Valve to first class condition.

All reconditioned Orbit Valves are given a new Valve guarantee and are, therefore, covered by our "Warranty"

IF YOU BUY OR SPECIFY VALVES

Be sure to order Orbit Valves. Long years of trouble-free service make Orbit Valves your best buy.

ORBIT VALVES ®

WAREHOUSES: HOUSTON, TEXAS, 407 Velasco, CApitol 8-6623, TWX HO 115; ODESSA, TEXAS, 402 West County Road, FEderal 7-2263, TWX ODESSA TEX 8041; LONG BEACH, CALIFORNIA, 1425 West 15th Street, HEmlock 7-6206; EDMONTON, ALBERTA, CANADA, 7119-104th Street, Phone 391-283

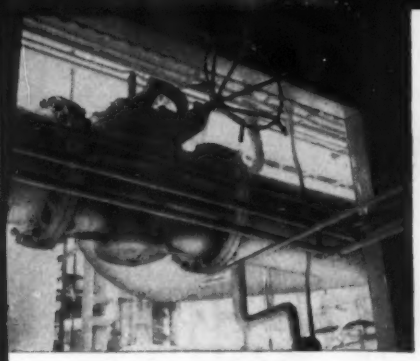
CANADIAN REPRESENTATIVE: T. R. Pickford & Company, Ltd., Calgary, Alberta, 536 8th Avenue West, Phone 2-7371

EXPORT REPRESENTATIVE: New York 36, N. Y., 500 Fifth Ave., BRyant 9-2236

where to save refining dollars

WITH

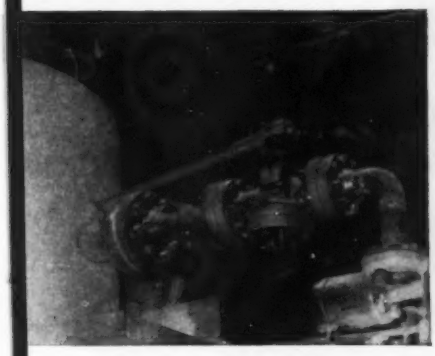
ROCKWELL-Nordstrom **VALVES**



CATALYTIC CRACKING
From the smallest valves to the large emergency flow line valve above, Rockwell-Nordstrom valves keep process units on stream without costly down time. Lubricant stops valve trouble *before* it has a chance to start.

CATALYTIC POLYMERIZATION
The Rockwell-Nordstrom valve shown above on the reactor feed line insures trouble-free flow control. Since the plug is fully opened or closed with just a quarter-turn, gear operation is two to five times faster than ordinary valves.

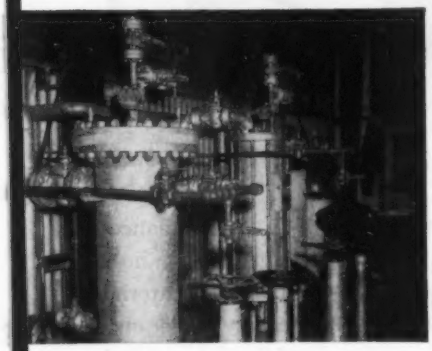
GAS SERVICE
On intake or discharge gas lines, Rockwell-Nordstrom valves—20″ valve shown above—operate easily and won't stick. The perfectly seated plug is "cushioned" on pressurized lubricant for instant, easy operation.



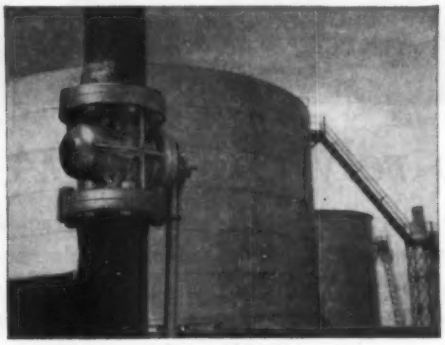
GAS SYNTHESES
Where leakage is not only troublesome, but hazardous, you'll often see Rockwell-Nordstrom Hypreseal valves like the ones shown above. Pressurized lubricant in the sealing grooves acts like a *permanent soft seat* that is instantly replaceable.

PROCESS LINES
On cat cracker process lines Rockwell-Nordstrom valves stay trouble-free month after month. Lubrication of valves on services like this is positive protection against costly valve failures. And Rockwell-Nordstrom valves can be quickly and easily lubricated or adjusted without down-time.

SULPHUR RECOVERY
Tough services like sulphur production are easy for Rockwell-Nordstrom lubricated plug valves. Seating areas are *never* exposed to the line and the tough film of lubricant insures a bottle-tight seal on services where other valves fail quickly.



AMMONIA
The little (1″) Rockwell-Nordstrom valves on the Ethylene and Methene service above do a big job of trouble-free, leakproof flow control. In any size, Rockwell-Nordstrom valves take less space and can be manifolded far tighter than ordinary valves.

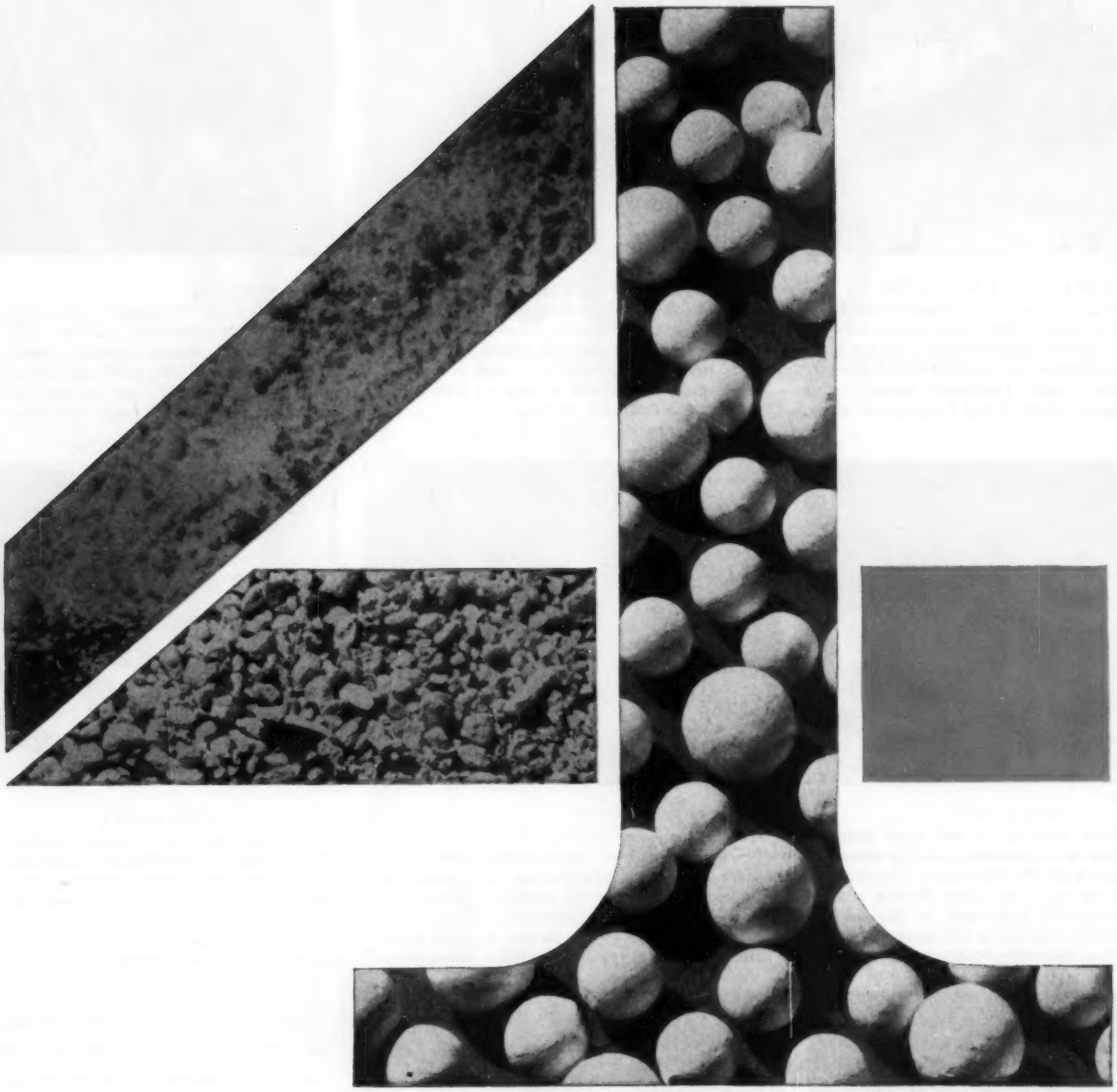


STORAGE AND TRANSFER
Rockwell-Nordstrom valves will prove profitable throughout the transfer and storage system. Select from a *complete* line of valves and from a wide variety of operating accessories to answer your every flow control need. Positive shut-off stops product contamination and leakage hazards.

Refinery maintenance records all over the country prove that you can't make a better valve investment than Rockwell-Nordstrom. No matter what your valve requirements, there is a Rockwell-Nordstrom lubricated plug valve that will do the job better and at far lower cost. And they cost no more to buy, often less, than ordinary valves. Write today for complete details. Rockwell Manufacturing Company, Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited.

ROCKWELL-Nordstrom VALVES

Lubricant Sealed For Positive Shut-off



good reasons to rely on ALCOA ALUMINAS

Need top performance catalysts or catalyst supports . . . long-life refractory ingredients . . . performance-proved desiccants . . . binders, fillers and pigments for product formulations . . . or raw materials for a host of other uses? Here are four excellent reasons to rely on ALCOA® Aluminas for your chemical material needs . . . *STABLE PRICES:* increasing tonnage sales plus continuing improvements in efficiency and equipment have kept prices of Alcoa Aluminas low and uniform for over 20 years—a record nearly unparalleled in heavy chemicals! . . . *UNIFORM QUALITY:* painstaking attention to quality assures uniform chemical and physical characteristics for every type and grade of ALCOA Aluminas—carload after carload after carload! . . . *ABUNDANT SUPPLIES:* produced in vast amounts, primarily for the aluminum industry, ALCOA Aluminas are available to you in almost unlimited quantities. You can always count on *DEPENDABLE DELIVERY* of the full quantity you need, *when* you need it.

Don't suffer from raw chemical price fluctuations, impurities, supply deficiencies or delivery failures! Put dependable ALCOA Aluminas to work in *your* plant to eliminate those handicaps. Write today for complete information. ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 717-H Alcoa Building, Pittsburgh 19, Pennsylvania.

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

ALCOA CHEMICALS
ALUMINUM COMPANY OF AMERICA

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over 1,000,000 tons/yr of petrochemical know-how

- ammonia
- butadiene
- butyl rubber
- ethylene
- dodecyl benzene
- hydrogen
- methanol
- urea

MORE than twenty FW process installations totalling more than a million tons capacity per year are now in operation or under construction.

This specialized know-how — encompassing design, engineering, fabrication and erection all over the world — gives Foster Wheeler a firm foundation for serving the requirements of all producers planning process facilities in the expanding petrochemical industry.

Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.

FOSTER WHEELER

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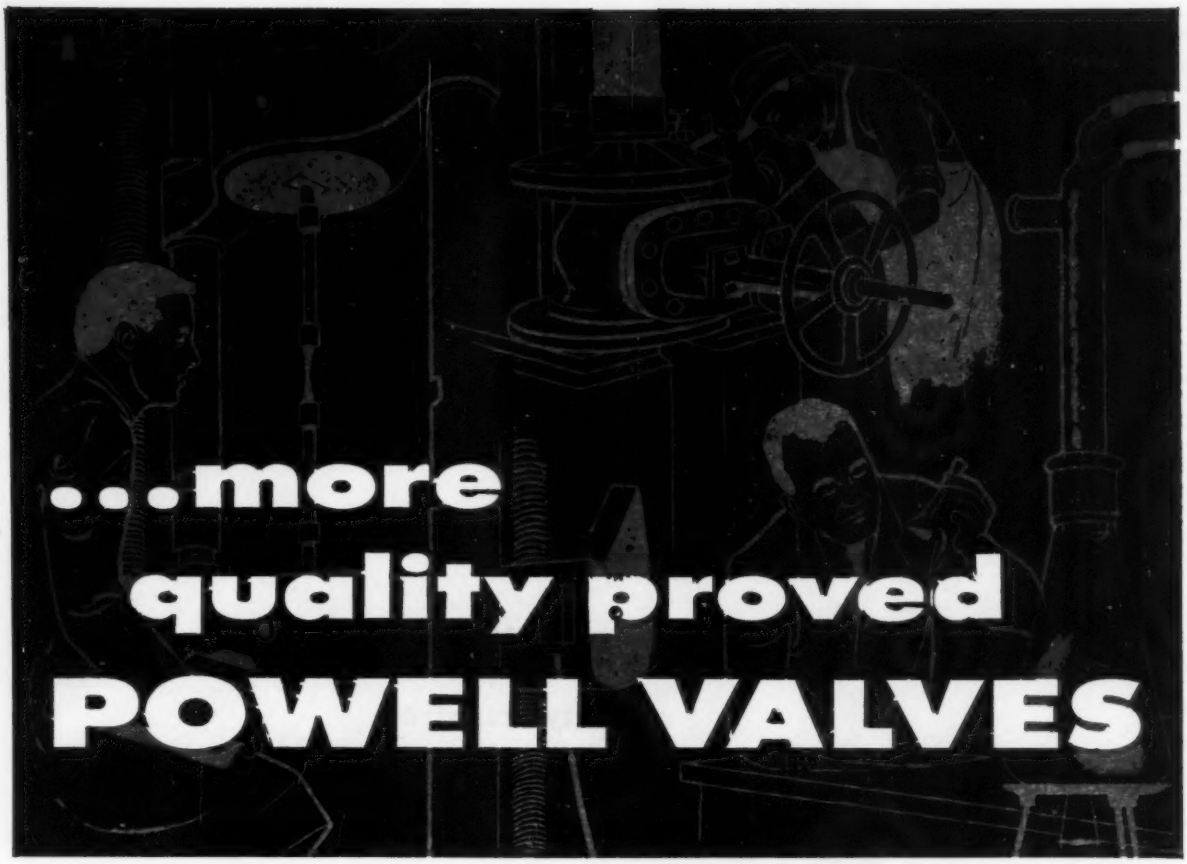
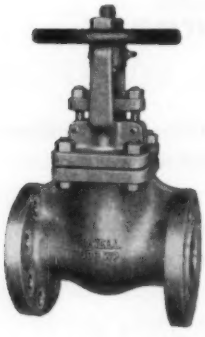


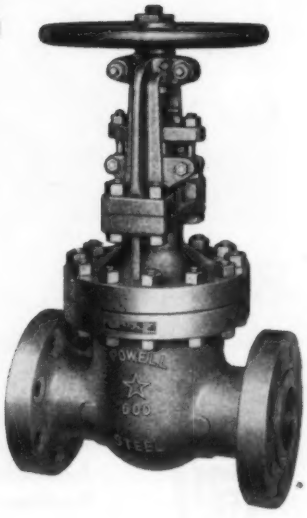
FIG. 375—Bronze "White Star" Gate Valve for 200 pounds W.S.P.

FIG. 2467—Stainless steel O.S. & Y. Gate Valve for 300 pounds W.P.

FIG. 6003—600-pound Steel O.S. & Y. Gate Valve

FIG. 3061—300-pound Steel Swing Check Valve





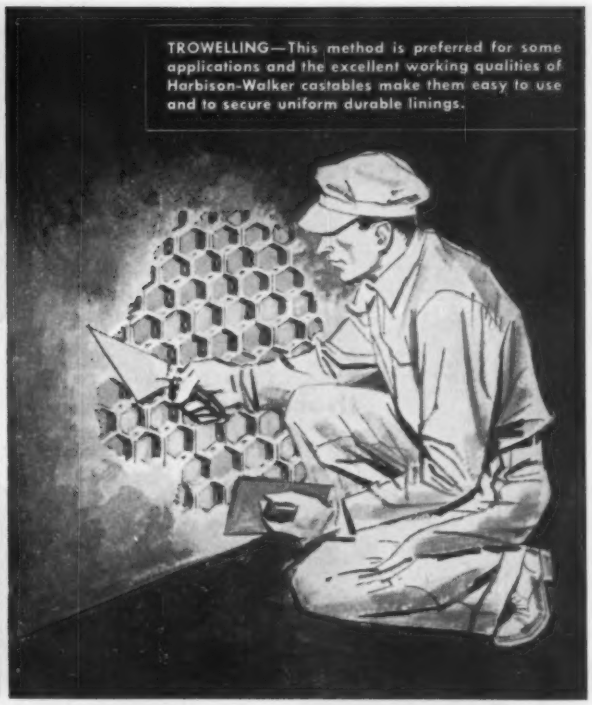
for dependable flow control

Consult your Powell Valve distributor for full facts about quality proved bronze, iron, steel and corrosion-resistant valves. For every flow control problem—there is a Powell Valve to solve it.

THE WM. POWELL COMPANY, CINCINNATI 22, OHIO . . . 111th YEAR

For more data on advertised products, use Readers' Service Cards, last page.

GUN APPLICATION—For many installations, Harbison-Walker castables are used to best advantage with various types of air placement guns.



TROWELLING—This method is preferred for some applications and the excellent working qualities of Harbison-Walker castables make them easy to use and to secure uniform durable linings.

For refractory linings that last longer...
specify HARBISON-WALKER

H-W EXTRA STRENGTH CASTABLE

H-W 56 LIGHTWEIGHT CASTABLE

Used together as illustrated, these two Harbison-Walker castable refractories form a lining that withstands the erosion, temperatures and pressures of refinery units, and provides highly effective insulation that reduces heat losses. Both products are particularly suited for service in catalytic cracking regenerators, reactors, catalyst feed lines and other units. They can be trowelled, poured like concrete, tamped or applied with air guns.

Write for complete information about these refinery-proved Harbison-Walker castable refractories.

Cross-sectional view shows H-W 56 Lightweight (insulating) Castable next to the regenerator shell, with H-W Extra Strength Castable superimposed for the working lining, where its high strength, excellent erosion resistance and low coefficient of expansion all contribute to long service life.

Harbison-Walker Refractories Company
AND SUBSIDIARIES
World's Most Complete Refractories Service
GENERAL OFFICES: PITTSBURGH 22, PENNSYLVANIA

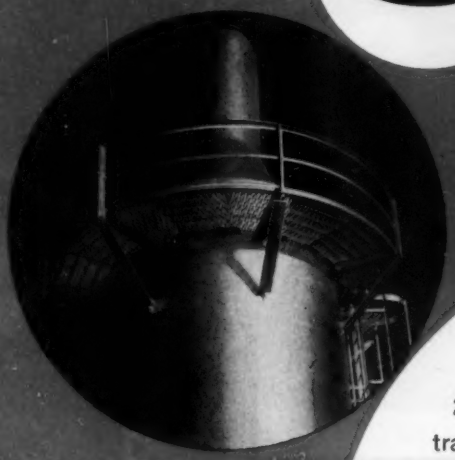
For more data on advertised products, use Readers' Service Cards, last page.

you can judge

the comparative values of furnace design as applied to operating requirements.

It's quite simple

there are **9** basic factors which must be evaluated to obtain the full comparison of values



1—Average radiant transfer rate. **2**—Maximum deviation from average radiant transfer rate. **3**—Average and maximum transfer rate in convection section. **4**—Maximum tube wall temperature, radiant or convection. **5**—Maximum efficiency with specified excess air. **6**—Controlled thermal recirculation of flue gases to provide even heat distribution throughout full length of each tube and equalized heat distribution around each tube. **7**—Overload and corresponding transfer load. **8**—Design to provide: structural column supports - Ladders - Platforms - Tube Removal facilities, etc. **9**—Degree of assembly; of the furnace structure and of the heating surface.

Whenever all these 9 specifications are applied to all the operating requirements, you can be sure PETROCHEM ISOFLOW FURNACES will be found most economically desirable.
No other furnace design can claim the recognition and acceptance achieved by PETROCHEM ISOFLOW FURNACES . . . starting with one installation in 1940, January '57 records more than 1650 ISOFLOW FURNACES in operation and under construction—a record that is incomparable just as all Petrochem Isoflow furnaces are more economically desirable by any comparison.

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

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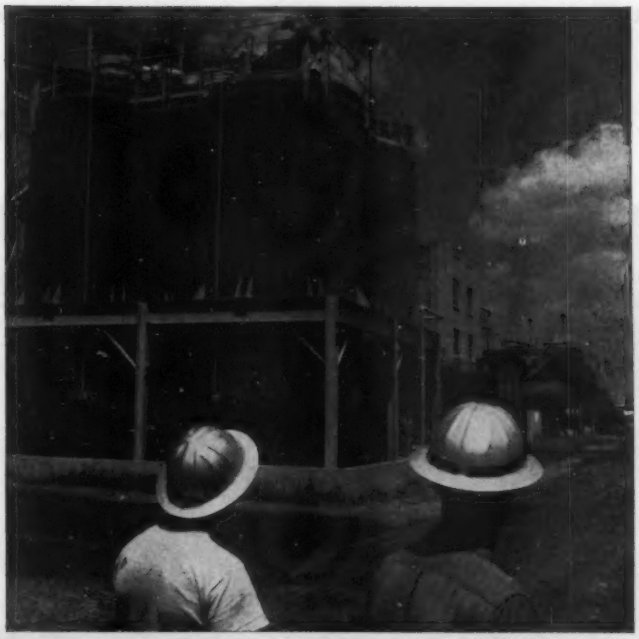
To protect process growth . . .

Take a new look at electrical system dependability



These chemical and petroleum companies did . . . and found new advantages in Westinghouse distribution equipment and engineering counsel.

American Cyanamid and Westinghouse Engineers worked out a power distribution system that prevents outages. If there's trouble on any feeder, power is switched to another. If a substation faults, other substations carry the load through cross connections. This system can be easily and inexpensively expanded as the plant grows.

Sohio's Lima Refinery achieves power dependability without paying extra for stand-by capacity. In a period of over two years, this Westinghouse equipped system handled power interruptions without loss of refinery production.

Get economy with system protection →

YOU CAN BE SURE... IF IT'S

Westinghouse

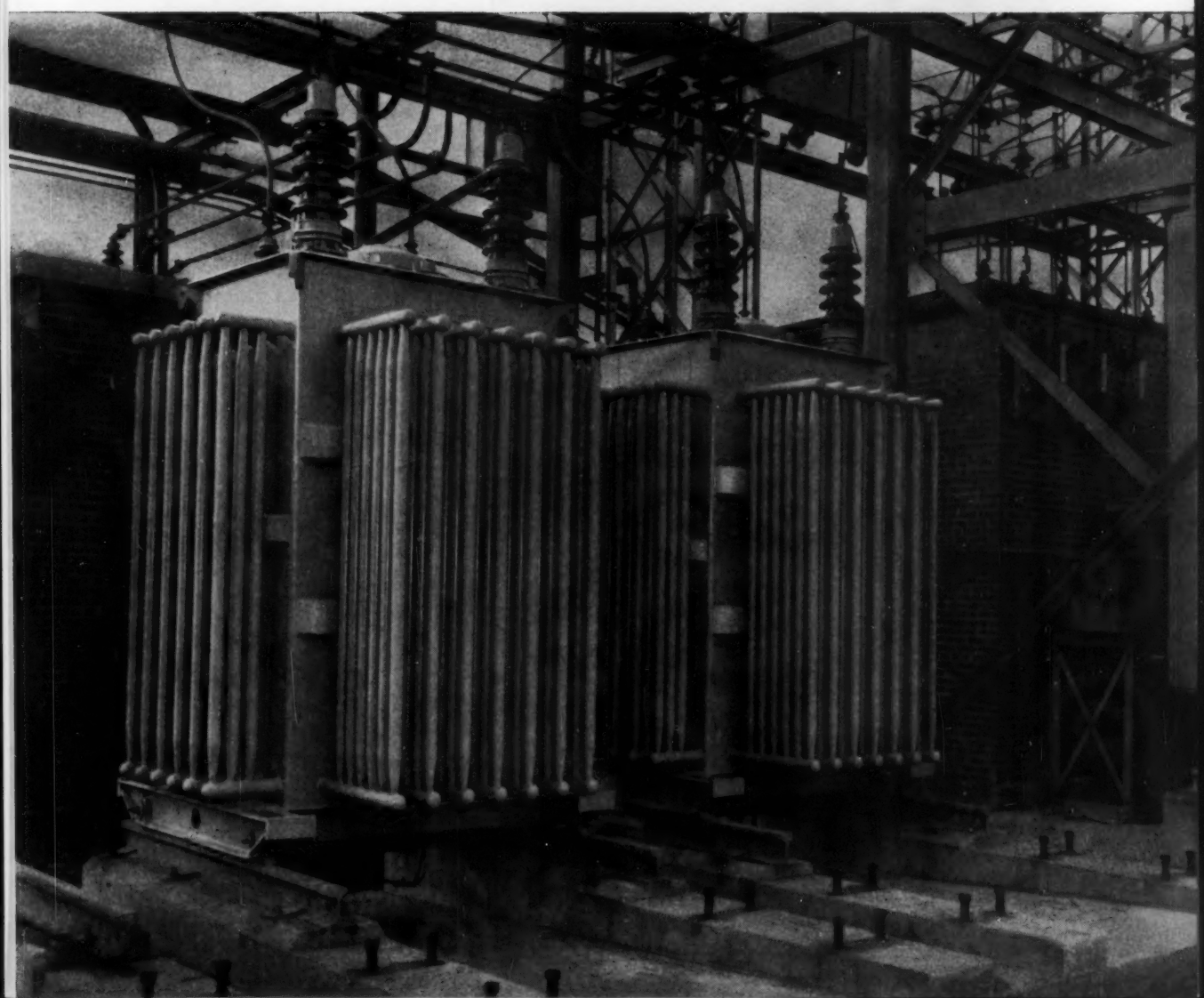
Call Westinghouse early to . . .

coordinate equipment for low cost, power dependability

Early planning of your power distribution system is the only effective way to answer these basic questions:

1. **How can I get the most reliability for dollars spent?**
2. **Will my electrical system be adaptable to changing load conditions with minimum service interruptions?**
3. **Can I get good voltage regulation in spite of load fluctuations?**

1. Standardized type SL transformers — liquid filled substation transformers for chemical use offer the many economies of Westinghouse standardization and design advantages based on years of tested and proved experience.



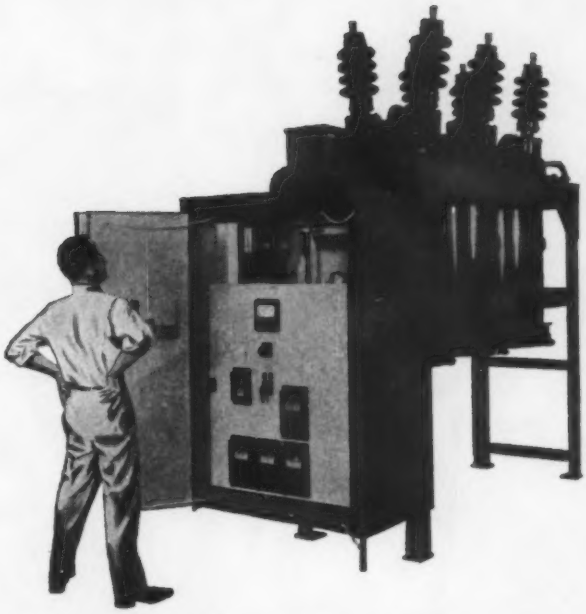
The choice of types of equipment and power distribution layout will depend on the problems in your plant . . . change-over, expansion, modernization, new processes or products. Westinghouse can help you select the right equipment and coordinate it to bring out the specific advantages that best suit your requirements.

Here are brief descriptions of the advantages you'll find in Westinghouse apparatus for a proven distribution system. They suggest many ways to provide maximum reliability without the expense of standby facilities.

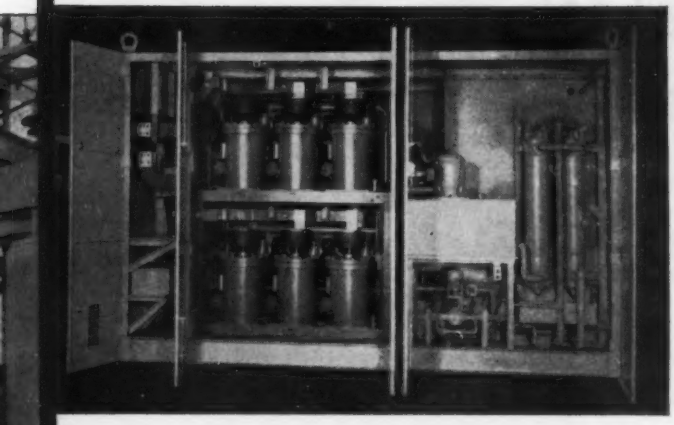
Discuss your plans with your Westinghouse Sales Engineer, or write: Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania.

MP-3054

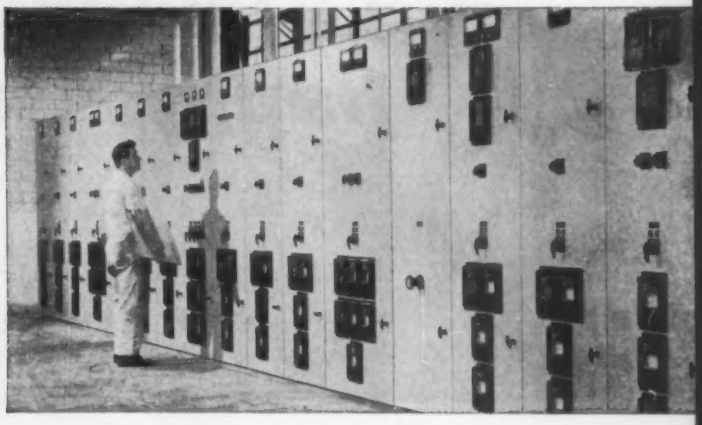
YOU CAN BE SURE...IF IT'S Westinghouse



2. Westinghouse oil circuit breakers with automatic reclosing equipment can automatically restore service to protect incoming lines or feeder circuits from prolonged and costly outages.

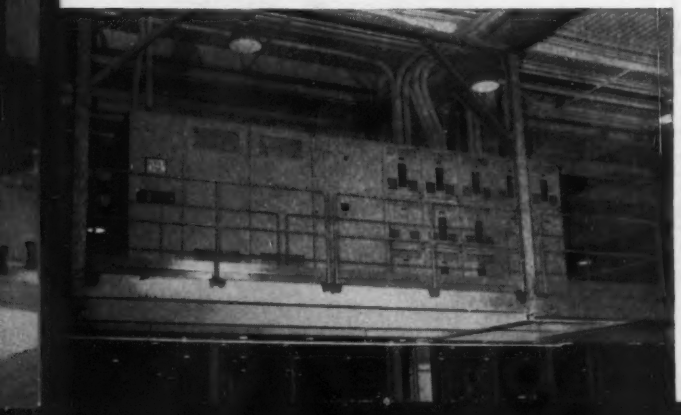


3. High availability and low maintenance of Westinghouse Ignitron Rectifiers has resulted in electrochemical installations totaling millions of kilowatts. Units are completely metal enclosed and factory assembled for low installation cost, minimum floor space.

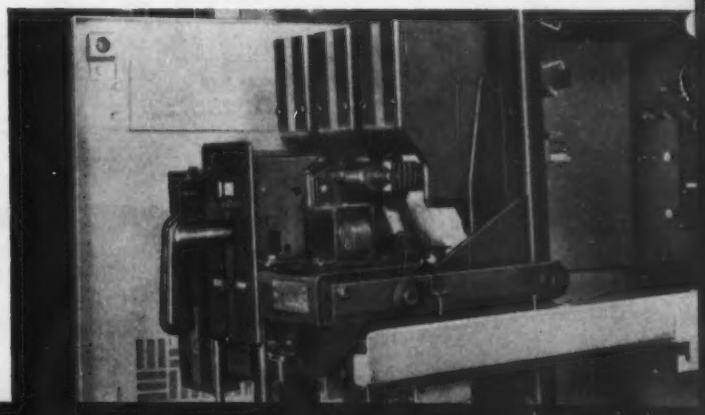


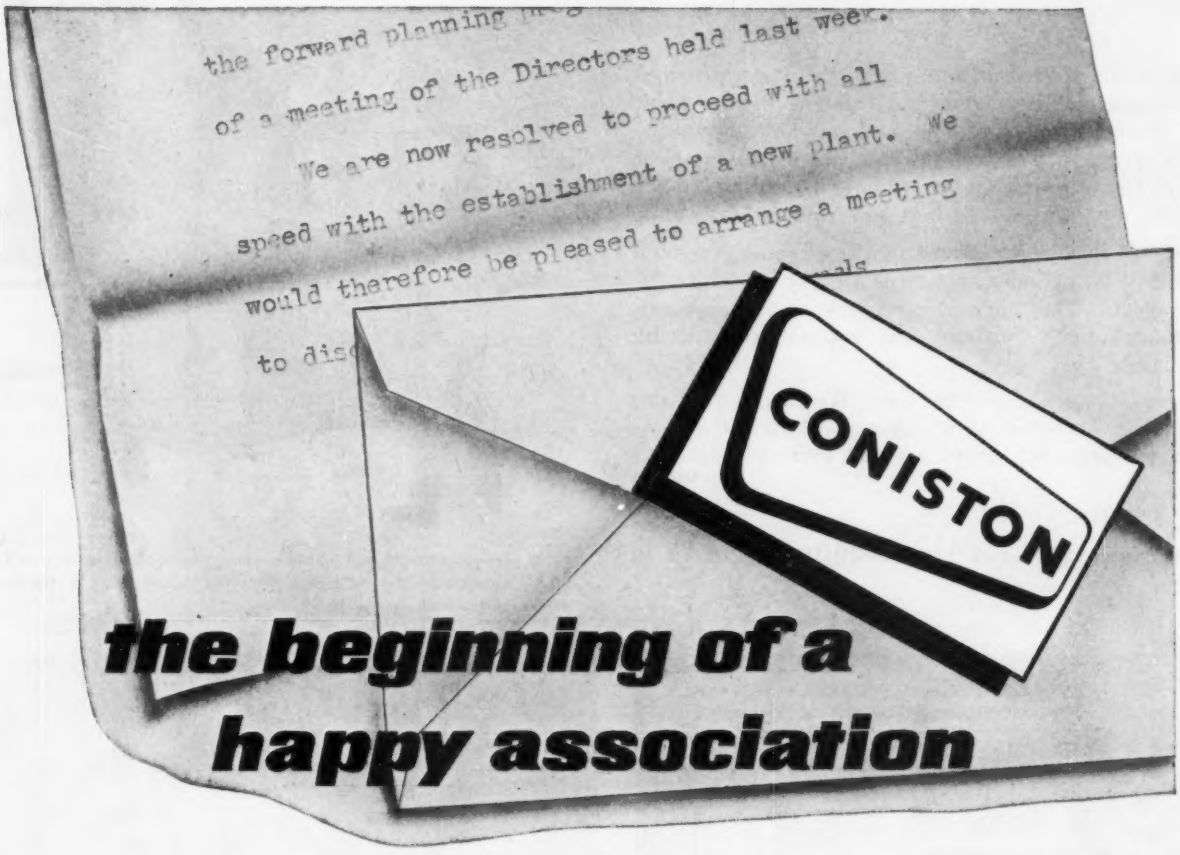
4. Westinghouse Metal-Clad High Voltage Switchgear provides unusual safety through interlocking devices and full steel barriers in a completely compartmentalized design.

5. Westinghouse unitized dry-type power centers solve the problem of handling increased power loads economically. They cost less to install because they do not require expensive enclosures and can be located close to the center of the load. For expansion, install additional breakers in spare feeder compartments.



6. Westinghouse low-voltage switchgear design provides an unusual degree of flexibility. This results from modern selective tripping. You get perfect coordination of time-delay characteristics, which confines outages to the faulted section alone.

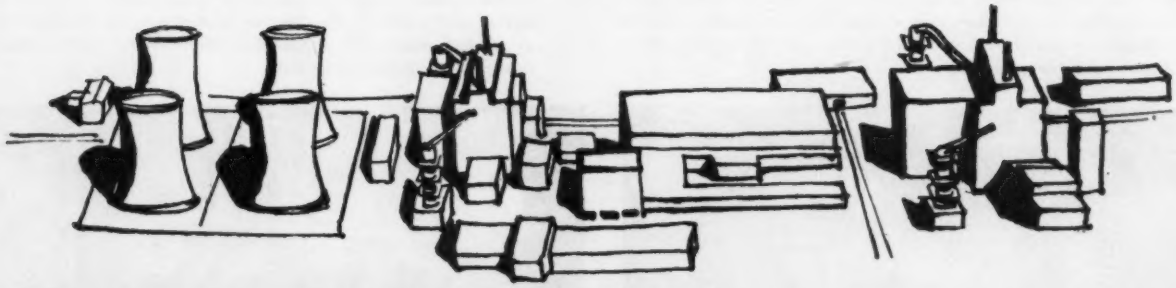



the forward planning
of a meeting of the Directors held last week.
We are now resolved to proceed with all
speed with the establishment of a new plant. We
would therefore be pleased to arrange a meeting
to dis
CONISTON
the beginning of a
happy association

that is how we like to feel about each new assignment. We talk things over at the planning stage, our experience meeting your problems, and make the responsibility ours right through until the project is a productive plant.

Our specialists in mechanical, chemical and petro-chemical engineering are always interested to discuss projects whether for a single process unit or a complete plant.

Your project is in capable hands with **CONISTON**



THE CONISTON COMPANY EAGLE HOUSE HIGH STREET WIMBLEDON SW19

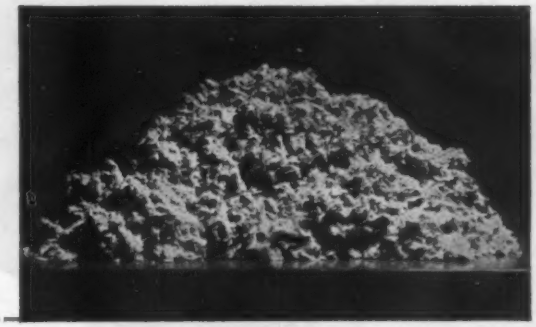
(Controlled by THE CONISTON ENGINEERING CO. LTD.)

TELEPHONE: WIMBLEDON 8521 TELEGRAMS: CONISTON TOOT LONDON (INLAND) CONISTON LONDON (OVERSEAS)

P3379

Refinery Insulation

All CAPOSITE moulded insulation materials are made of Amosite asbestos. The photograph clearly demonstrates the immense volume which is obtained when the natural Amosite is fiberised—the sign of high efficiency as an insulating medium.



CAPOSITE is supremely well suited to the thermal insulation of oil refineries. With a limiting temperature of 1000°F., high thermal efficiency and great structural strength and resilience, CAPOSITE has gained for itself a unique position among thermal insulation materials used by the Oil Industry.

CAPOSITE MOULDED ASBESTOS FIBRE PIPE INSULATION

EFFICIENCY DATA SHEET—PIPE SIZES 6" to 10" BORE.

HOT FACE TEMPERATURE °F.			400°F			600°F			800°F		
THERMAL CONDUCTIVITY K = B.Th.U. in./sq. ft./hr./in./°F.			0.43			0.47			0.53		
MEAN TEMPERATURE °F.			250			350			450		
Nominal Pipe Size	O.D. pipe	Thickness of Insulation	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.
6"	6¼"	1"	135	87·7	126	233	90·6	167	354	92·5	218
		1½"	102	90·8	107	177	92·9	135	270	94·3	171
		2"	83·6	92·4	97	145	94·1	118	223	95·3	145
		2½"	71·8	93·5	91	125	95·0	107	192	96·0	128
		3"	63·5	94·2	86	110	95·5	100	170	96·4	117
		3½"	57·3	94·8	83	100	96·0	95	154	96·7	109
		4"	52·6	95·2	81	91·7	96·3	91	142	97·0	103
8"	8⅝"	1"	130	88·0	127	225	90·8	169	341	92·7	222
		1½"	97·7	91·0	108	169	93·1	137	258	94·5	174
		2"	79·2	92·7	98	138	94·4	120	211	95·5	148
		2½"	67·4	93·8	92	117	95·2	109	180	96·1	131
		3"	59·2	94·6	87	103	95·8	102	159	96·6	120
		3½"	53·2	95·1	84	92·7	96·2	96	143	96·9	111
		4"	48·5	95·6	82	84·6	96·5	92	131	97·2	105

These figures are compiled from results of official tests by THE NATIONAL PHYSICAL LABORATORY, TEDDINGTON, computed in accordance with formulae shown in BRITISH STANDARD SPECIFICATION appendices.

Please write for full technical details

THE CAPE ASBESTOS COMPANY LIMITED
114 & 116 Park Street, London, W.1.
Cables: Incorrupt, London.

CAPOSITE REGD
Amosite Asbestos Blocks and Pipe Sections

Enquiries in CANADA to: Cape Asbestos (Canada) Ltd., 200 Bloor Street East, Toronto, Ont.
U.S.A.: The North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois.
SOUTH AFRICA: Cape Asbestos South Africa (Pty.) Ltd., P. O. Box 2533, Johannesburg; ITALY: Capamianto S.P.A., via Sant' Antonio 57, Turin. FRANCE: Isolamiante S.A. 37 Avenue Franklin D. Roosevelt, Paris 8e.

For more data on advertised products, use Readers' Service Cards, last page.

Model 24 R.C.M.
Miniature Recording Control Station

The new SUNVIC

miniature recording control station

Latest addition to the comprehensive Sunvic range of process control instrumentation is this miniature recording control station which is interchangeable with the Sunvic miniature indicating control station.

SPECIFICATION

Chart width of 3″ and speed of 1″ per hour.
Electric or pneumatic drive.
Fitted with auto/manual switching.
Continuous record of process and indication of set-point pressure and valve position.
Also available as single or two-pen recorder.

EXCELLENT PERFORMANCE

Accuracy : better than 0.5%
Deadspot : less than 0.8%

EASY MAINTENANCE

Chassis withdraws from front, providing easy access to mechanism and all interior adjustments. All zero adjustments from front panel. No ink filling—expendable reservoir holds six months' supply.

EXTREMELY ADAPTABLE

Fitted with manifold to accept any Sunvic 'plug-in' stack controller; also available for direct piped connections. Easily converted for use in cascade control.
Dimensions and specifications are given in Bulletin 241. Write for a copy today.

SUNVIC

Not only instruments but complete instrumentation

for integrated monitoring control and data handling of nuclear reactors and industrial processes.

SUNVIC CONTROLS LIMITED, No. 1 FACTORY, TEMPLE FIELDS, HARLOW, ESSEX
Telephone : Harlow 24231/5

An A.E.I. Company

SC/55

ALUNDUM* Catalyst Carriers and Supports

are proved aids to better, lower cost processing

Norton ALUNDUM catalyst carriers have excellent mechanical, thermal and chemical stability. They are crystalline in nature and are produced in two surface area types: Intermediate (5-70m²/gram) and Low (less than 1m²/gram).

The alumina content of the intermediate carriers is approximately 77%. These are subdivided into Types A, B and C, with varying characteristics. In the low surface area carriers, the alumina content ranges from 77% to 92%.

PHYSICAL PROPERTIES

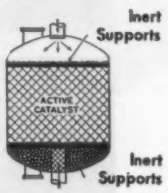
	Apparent Porosity	Water Absorption	Bulk Density	Vol. Bulk Density	Crystal Structure	Surface Area
Intermediate Surface Area Type A	45-50%	28-30%	.65-1.70 gr/cc	38 lbs/ft³ (Approx.)	Quartz, Alpha, Gamma Alumina — chiefly Gamma Alumina	60-70m²/gram
Type B	45-50%	28-30%	1.65-1.70 gr/cc	60 lbs/ft³ (Approx.)	Quartz, Alpha, Kappa, Delta Alumina	20-30m²/gram
Type C	45-50%	28-30%	1.65-1.70 gr/cc	62 lbs/ft³ (Approx.)	Alpha Alumina and Mullite	5-10m²/gram
Low Surface Area	10-50%	3-25%	1.90-3.15 gr/cc	65-80 lbs/ft³	Alpha Alumina and Mullite	Less than 1m²/gram

Some Of Many Applications

Suggested Applications For Intermediate Surface Carriers include catalytic reforming, dehydrogenation, dehydration, sulfuric acid manufacture, nitric acid manufacture and dessicants.

Low Surface Area Carriers are used in the processing of phthalic anhydride, maleic anhydride and ethylene oxide; also in protective atmospheres and synthetic gas generation.

Suspending Active Catalysts Effectively



In fixed bed convertors where it is necessary to suspend active catalysts at a given level, supports produced by Norton are used successfully. Made of dense, rugged, electrically fused materials these supports have great resistance to breakdown and have no chemically reactive effect on the processing.

Get More Facts

on how Norton catalyst carriers and supports can improve and economize your processing. On request, they can be prepared from other materials such as: CRYSTOLON* silicon carbide, MAGNORITE* fused magnesia, zirconium oxide, silica, etc. Call in your Norton Refractories Engineer or write, mentioning your requirements, to NORTON COMPANY, Refractories Division, 467 New Bond St., Worcester 6, Massachusetts.

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed
Making better products... to make your products better

NORTON PRODUCTS:
Abrasives • Grinding Wheels
Grinding Machines • Refractories
BEHR-MANNING PRODUCTS:
Coated Abrasives • Sharpening Stones
Behr-cat Tapes
*Trade-Marks Reg. U.S. Pat. Off. and Foreign Countries

For more data on advertised products, use Readers' Service Cards, last page.

Let Harshaw Catalysts do a GIANT'S work for you

Harshaw Catalysts do a giant's work and Harshaw produces catalysts in giant quantities—carloads every week. A letter or phone call will put our 20 years' experience and acres of production and research facilities to work for you.

PREFORMED CATALYSTS
to fit special process requirements

Hydroforming
Cyclization
Oxidation
Dehydrogenation
Dehydration
Desulphurization
Alkylation
Isomerization
Hydrogenation

CATALYTIC CHEMICALS SUPPLIED BY HARSHAW

Aluminum Nitrate — Cobalt Nitrate
Copper Nitrate — Manganese Nitrate Solution
Metallic Soaps (Cobalt, Manganese)
Nickel Carbonate — Nickel Formate — Nickel Nitrate
Nickel Sulfate — Sodium Methoxide — Zinc Nitrate

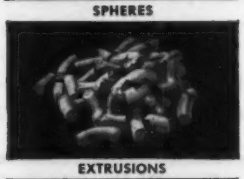
Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

Write for Free Book

THE HARSHAW CHEMICAL CO.
Chicago • Cincinnati • Cleveland • Detroit • Hastings-On-Hudson
Houston • Los Angeles • Philadelphia • Pittsburgh

TABLETS

SPHERES


EXTRUSIONS

GRANULES

POWDERS

FLAKES

For more data on advertised products, use Readers' Service Cards, last page.

S & J GARDTROL® provides

Positive remote supervisory control of pump motors and valves

Two complete packaged remote control systems are now available for application to distant motor operated valves and electric pump motors. Gardtrol Valve and Pump Motor Monitors provide constant monitoring and positive, non-ambiguous indication of "on", "off", "open", "closed" and "stopped" conditions at remote stations. Both units feature simplified design—three components, a control unit, field unit and single wire transmission line provide efficient, economical controlling. Exclusive Gardtrol circuit utilizes the cyclically-reversing polarity of alternating current to effect both control and supervision over one wire. Distance is limited only by the resistance of the signal wire.

two packaged units

GARDTROL VALVE MONITOR
opens, closes or stops valves in any position

GARDTROL PUMP MOTOR MONITOR
indicates off, on, and stops motors

Call or write your nearest Shand and Jurs office for specifications and prices.

SHAND AND JURS CO.
8th and Carleton Streets, Berkeley, California

a subsidiary of General Precision Equipment Corporation

NEW YORK	TULSA	LOS ANGELES	HOUSTON	CHICAGO
110 E. 42nd St.	Thompson Bldg.	6399 Wilshire Blvd.	M & M Bldg.	10409 S. Western Ave.

REPRESENTATIVES

SEATTLE: Nebar Supply Company, 3000 Western Ave. **MONTREAL:** Lytle Engineering Specialties, Ltd., 360 Notre Dame St., W. **TORONTO:** Lytle Engineering Specialties, Ltd., 69 Eglinton East. **VANCOUVER:** P. D. McLaren & Son, Ltd., 3277 Main St. **CALGARY:** P. D. McLaren & Son, Ltd., 510 - 9th Ave., W. **MEXICO, D. F.:** Dalma Comercial, S. A. **CARACAS:** Sinclair Spence, C. A., Edificio Galipan. **ENGLAND:** Whessoe, Ltd., Sales: 25 Victoria St., London S. W. 1 Whessoe, Ltd., Works: Darlington, County Durham

4414

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1

NIAGARA FALLS, N. Y.
50% and 73% Liquid (in tank cars)

6 reasons why Mathieson CAUSTIC SODA is always there

2

SALTVILLE, VA.
50% and 73% Liquid (in tank cars)
76% Solid, Flake, Granular, and Ground (in drum shipments)

. . . an Olin Mathieson plant is near you.

. . . your source of supply is constantly backed up by five other plants.

For specifications and schedules, call your Olin Mathieson sales representative.

3

HUNTSVILLE, ALA.
50% and 73% Liquid (in tank cars)
50% Liquid (in barges)

4

BRUNSWICK, GA.
50% Liquid (in tank cars and barges)

5

McINTOSH, ALA.
50% and 73% Liquid (in tank cars)
50% Liquid (in barges)

6

LAKE CHARLES, LA.
50% and 73% Liquid (in tank cars)
50% Liquid (in barges and tankers)
76% Solid and Flake
(in drum shipments)

MATHIESON

MATHIESON CHEMICALS
OLIN MATHIESON CHEMICAL CORPORATION
INDUSTRIAL CHEMICALS DIVISION • BALTIMORE 3, MD.

INORGANICS: Ammonia • Bicarbonate of Soda • Carbon Dioxide • Caustic Potash • Caustic Soda • Chlorine • Hydrazine and Derivatives • Hypochlorite Products • Muriatic Acid Nitrate of Soda • Nitric Acid • Soda Ash • Sodium Chlorite Products • Sulfate of Alumina • Sulfur (Processed) • Sulfuric Acid

ORGANICS: Ethylene Oxide • Ethylene Glycols • Polyethylene Glycols • Glycol Ether Solvents • Ethylene Dichloride • Dichloroethylether • Formaldehyde • Methanol Sodium Methylate • Hexamine • Ethylene Diamine • Polyamines • Ethanolamines • Trichlorophenol • Surfactants

4920

because of GLYCOLS *and* ETHANOLAMINES

Wet or sour gases, once flared as a nuisance, now produce millions in revenue — thanks to the glycols and ethanolamines. If you use these versatile chemicals for gas dehydration or purification, you want to be sure of steady supply and instant service. Allied glycols and ethanolamines are available in tank car lots from Nitrogen Division's Orange, Texas plant, and in tank trucks or drums from warehouses in principal producing areas. Allied's technical specialists are always on call to help with any application problems you may have.

Dept. GA 1-21-3

Allied Chemical — Nitrogen Division

40 Rector Street, New York 6, N. Y.

Ethanolamines • Ethylene Oxide • Ethylene Glycols • Urea • Formaldehyde • U. F. Concentrate—85 • Anhydrous Ammonia • Ammonia Liquor • Ammonium Sulfate • Sodium Nitrate • Methanol • Nitrogen Solutions • Nitrogen Tetroxide • Fertilizers & Feed Supplements

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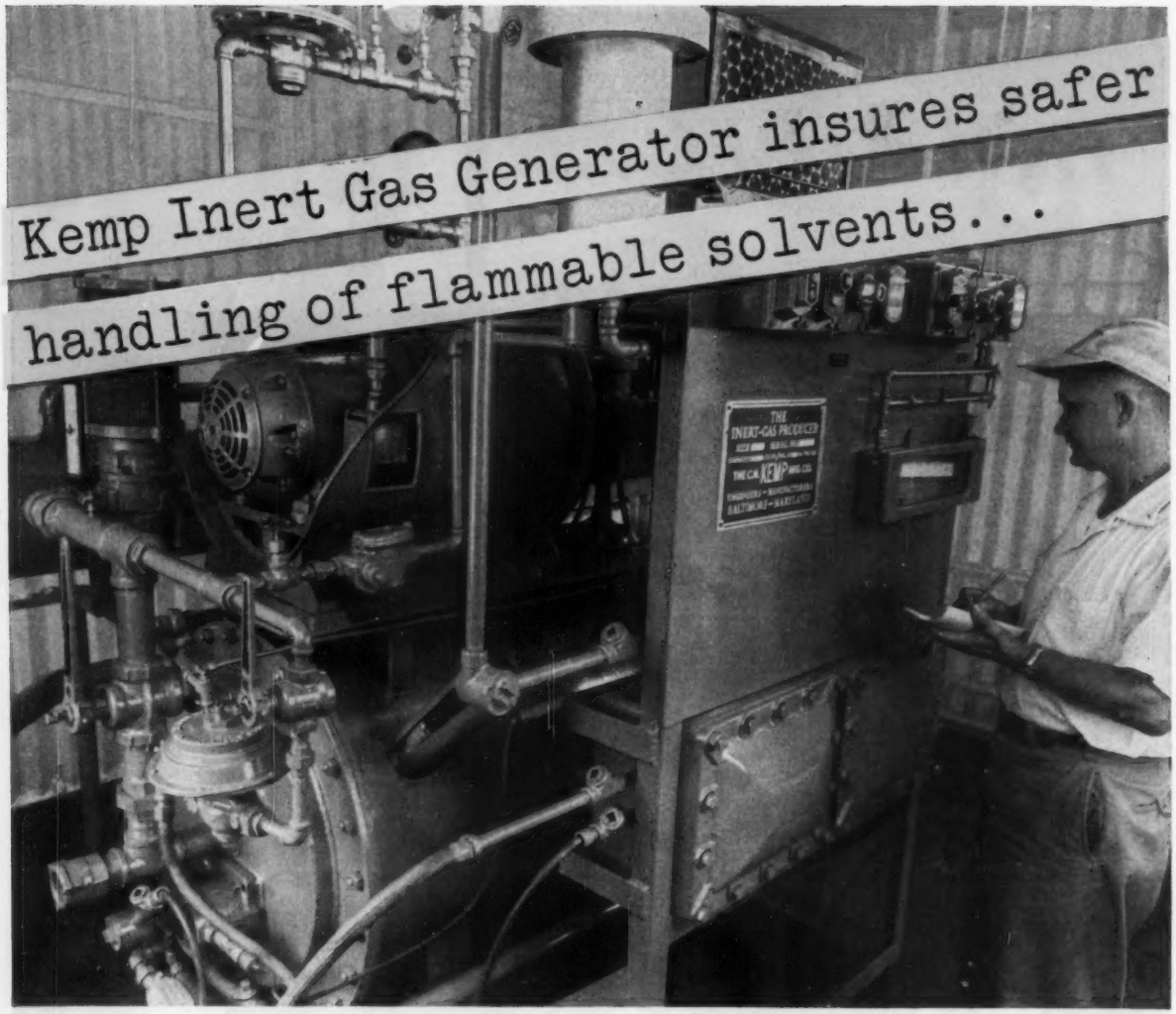


Quaker State reports:

Kemp Generator maintains steady inert gas supply for blanketing—even under varying load conditions!

In this Quaker State Oil Refinery, in Farmer's Valley, Pa., a Kemp 3,000 cu. ft. per hr. Generator is used to provide inert gas atmosphere to blanket vessels containing flammable solvents. Mr. Joe O. Brown, Process Engineer, says that the Kemp Generator, in use since 1949, is a big improvement over a previous model replaced by this 3-MIHE.

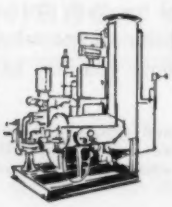
Kemp does all inert gas jobs better

Kemp Gas Generators are easier to operate, start quickly, give continuous output around the clock. Even under fluctuating loads uniform analysis is maintained. Pipelines and vessels can be purged easily, quickly, for cleaning and inspection or when processes are changed! Kemp Generators are also ideal for annealing, hardening, and sintering. Kemp has the ability to produce a chemically clean inert at a specific analysis *regardless* of demand!

Investigate NOW

Find out how Kemp Engineers can provide the most profitable answer to *your* inert gas problem! Write for Bulletin I-10 today.

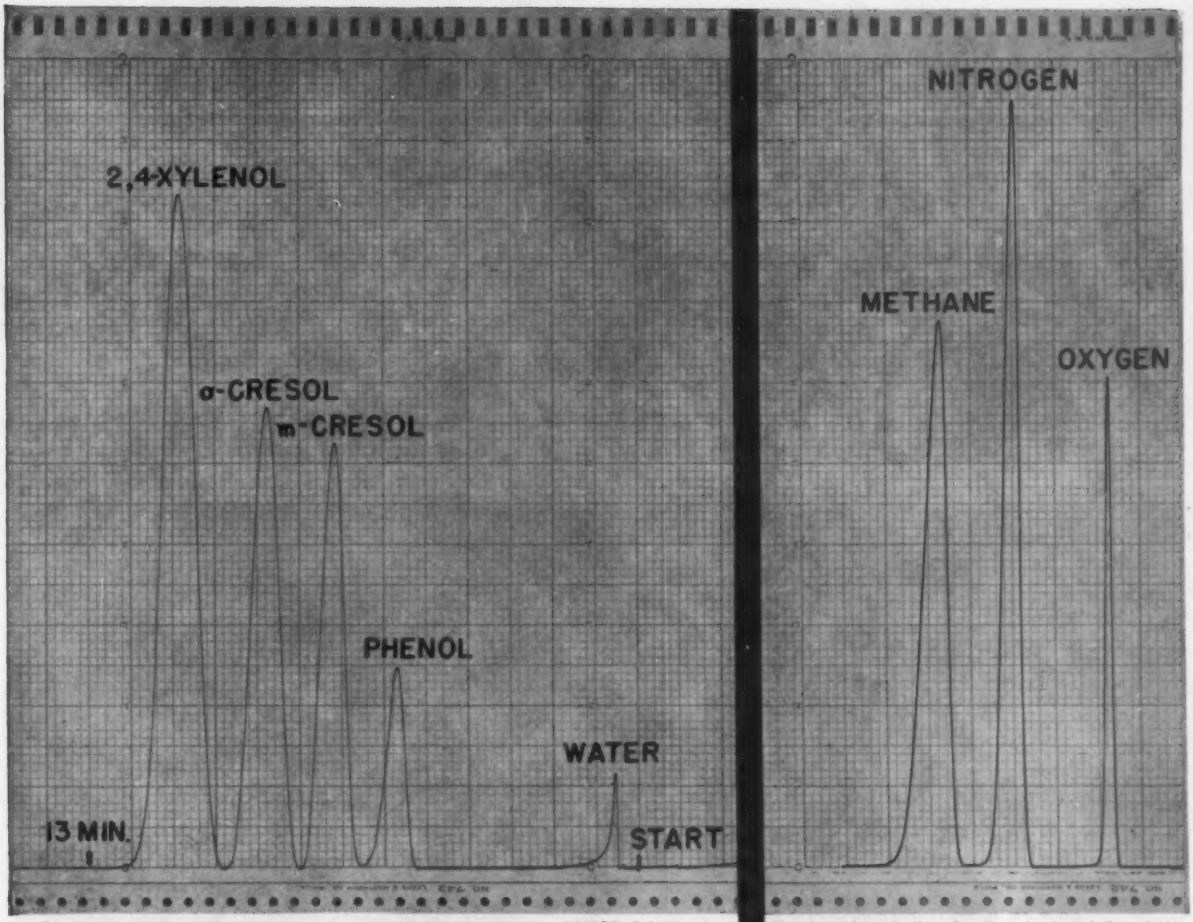
KEMP OF BALTIMORE



INERT GAS GENERATORS

CARBURETORS • BURNERS • DYNAMIC DRYERS
FIRE CHECKS • METAL MELTING UNITS
SINGEING EQUIPMENT

THE C. M. KEMP MFG. CO.
405 East Oliver Street, Baltimore 2, Maryland



Run shows separation of high boiling components at column temperature of 190°C. 2,4-xylenol which boils at 211°C is separated in 11 minutes. Good resolution of other components is obtained.

The above determination of methane in air took five minutes. Other light gases boiling below 20°C are rapidly separated.

New P-E Model 154-B Vapor Fractometer

ANALYZES LIQUIDS BOILING UP TO 300°C

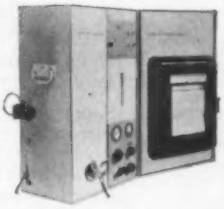
extends range of previous model by 50°

The fast, precise technique of gas chromatography can now be applied to the analysis of esters, cresols, phenols, xylenols, chlorinated aromatics and high alcohols boiling at 300°C or below with P-E's new Model 154-B Vapor Fractometer. Small laboratories just getting into gas chromatography work find it well suited to their needs while laboratories performing a high volume and wide range of chromatographic analyses can use the full range and versatility of the instrument. P-E's Vapor Fractometers are the most widely used gas chromatography instruments.

CHECK THESE FEATURES

- Continuously adjustable temperature control from 20°C to 225°C.
- Most sensitive dual thermal conductivity detector available with a detectability reaching 1 part in 100,000.
- Precise recorder range control in steps of 2 over range of 1 through 512 for accurate trace and high concentration analysis.
- Reproducible liquid (and gas) sampling accessory for introduction of exact sample volume.
- Reproducible gas sampling valve.*
- Sample collection outlet necessary for collecting eluted pures for reuse or identification by auxiliary methods such as infrared, ultraviolet, or mass spectroscopy.

*U.S. Patent No. 2,757,541



Write for the new 16-page booklet on the Model 154-B, including sampling features and performance runs of ten different column materials.

INSTRUMENT DIVISION

Perkin-Elmer *Corporation*

NORWALK, CONNECTICUT

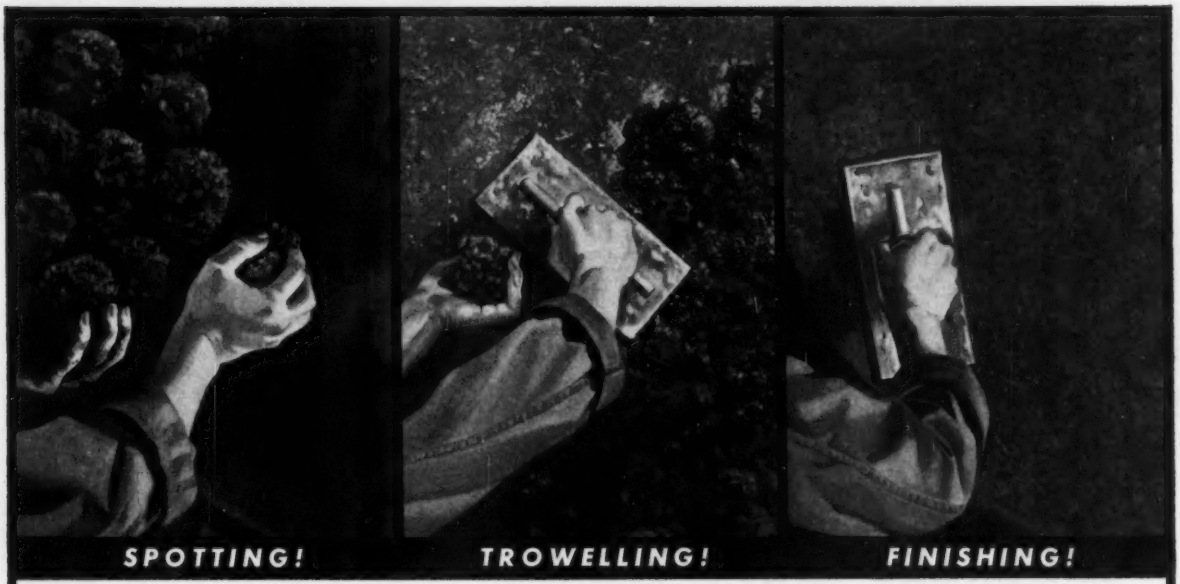
For more data on advertised products, use Readers' Service Cards, last page.

IT STICKS TO HOT OR COLD SURFACES!

EAGLE-PICHER

SUPER "66"

INSULATING CEMENT



SPOTTING! TROWELLING! FINISHING!

- Because it sticks, Super "66" saves time—applies quickly to any equipment, cold or hot! Effective up to 1800 F.
- Because it sticks, Super "66" saves money—provides far greater coverage and more efficient insulation.
- Because it sticks, Super "66" makes difficult jobs easy—can be used on irregular shapes where application of other insulations is often impossible. Usually requires no reinforcing on applications up to 1½ inches thick.
- Unique "springy ball" structure of small, resilient mineral wool pellets results in maximum efficiency—maximum fuel savings!
- Super "66" contains a special rust inhibitive which actually prevents corrosion!

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with low iron content

B&W Kaocast

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B&W Kaocrete-LI

After two years of extensive field service, B&W adds Kaocrete-LI to low iron content castables. B&W Kaocrete-LI, which has an iron content of less than 1%, has exceptionally high strength for resistance against abrasion and erosion. It has sufficient refractoriness for use at temperatures to 2700 F. Suitable for both gunning and casting.

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Properties of B&W Low Iron Content Castables

		B&W Kaocast	B&W Kaocrete LI	B&W Kaolite LI	B&W Kaocrete 32
Use limit, °F		3000	2700	2300	3200
Melting point, °F		3200	3100	2700	3297
Average density lb/cu ft after firing		126	131	59	134
Average % Fe_2O_3		1.0	0.9	0.8	1.0
Cold crushing strength—psi average—after heating for 5 hrs. at:	1000 F	700	2500	350	1000
	1500 F	500	2500	350	800
	2000 F	400	1200	300	750
	2200 F	500	1300	450	1000
	2400 F	500	1600	—	2000
	2600 F	1000	6000	—	3000
	2800 F	2200	—	—	3500
	3000 F	3500	—	—	4000
	3200 F	—	—	—	5000
Permanent linear shrinkage—average % less than—after heating for 5 hrs. at:	1000 F	0.3	0.2	0.3	0.2
	1500 F	0.3	0.2	0.4	0.2
	2000 F	0.5	0.2	0.4	0.2
	2200 F	0.5	0.2	0.6	0.4
	2400 F	0.5	+0.1	—	0.5
	2600 F	0.5	—	—	0.5
	2800 F	0.5	—	—	0.5
	3000 F	0.3	—	—	0.2
	3200 F	—	—	—	0.1

Consult your B&W Representative for additional information on these and other B&W Refractories for the refining industry.

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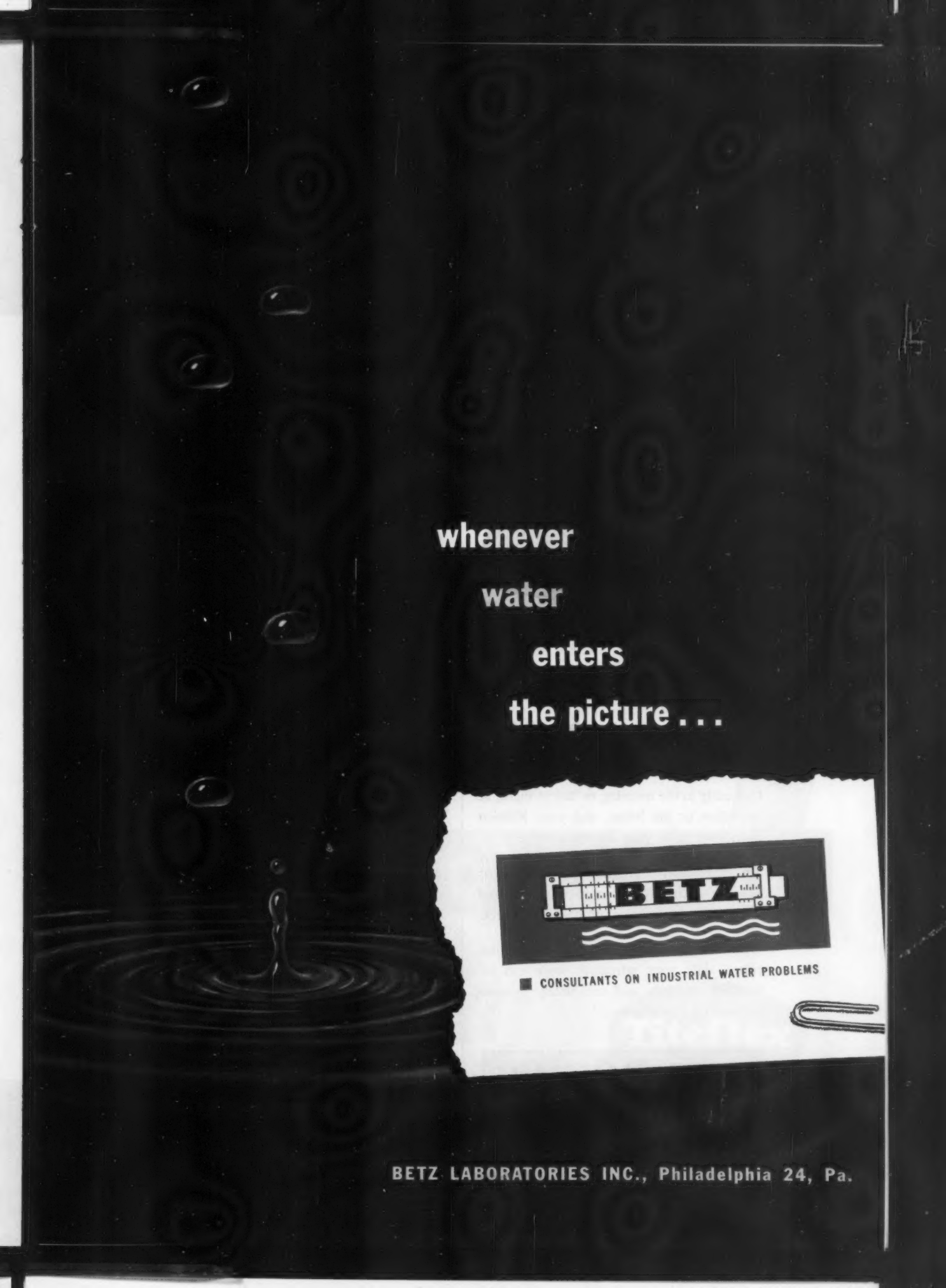
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Nomenclature Omitted

The Nomenclature for the article by C. D. Holland and W. B. Hayes, "Steam Flash Vaporization of Multicomponent Mixtures" by mistake was omitted from the April, 1957 issue of PETROLEUM REFINER and is reproduced below. The Holland-Hayes article starts on Page 203 of that April issue.

NOTATION

a = a constant for a given flash vaporization; defined by equation (2).
F = total moles of volatile and non-volatile components in the feed; moles/unit time.
$F_t = F + S$ = total moles of feed, moles/unit time.
$f(\Theta)$ = function of L/F; defined by equation (11).
$f(\Theta_a), f'(\Theta_a)$ = value of the function and its first derivative at $\Theta = \Theta_a$; $f'(\Theta)$ is given by equation (12).
L = total moles liquid formed in flash; includes all volatile and non-volatile components and excludes steam; moles/unit time.
L_i° = moles of any one of the volatile components in the feed (does not include steam); moles/unit time.
L_t° = total moles of volatile components in the feed (does not include steam); moles/unit time.
P_b = vapor pressure of volatile component, selected as the base component, at the temperature of the flash; $\alpha_i = P_i/P_b$.
P_i = vapor pressure of pure component i at the temperature of the flash.
p_i = partial pressure of component i in the total vapor leaving the flash zone.
P_s = vapor pressure of steam at the temperature of the flash.
p_s = partial pressure of steam in the total vapor leaving the flash zone.
S = moles of steam entering and leaving the flash zone in the vapor state; moles/unit time.
V = moles of volatile components in vapor (does not include steam); moles/unit time.
$V_t = V + S$ = total moles of vapor leaving the flash zone; moles/unit time.
X_{fi} = total mole fraction in total feed, for all volatile and non-volatile components; $X_{fi} = Fx_{fi}/F_t$; for steam $X_{fs} = S/F_t$.
x_{fi} = mole fraction of any volatile or non-volatile component in the feed, F.
x_i = mole fraction of any volatile or non-volatile component in the liquid, L, leaving the flash zone (see case one). In second case treated, i does not refer to the non-volatile components, $i \neq r$.
y_i = mole fraction of component "i" in the total vapor (volatile components plus steam); y_s = mole fraction of steam in the total vapor.

Greek Symbols

α_i = relative volatility of component i with respect to component b; $\alpha_i = P_i/P_b$.
π = total pressure in the flash zone.
Σ = summation over all components.
$\Sigma_{i \neq s}$ = sum over all components except steam.
$\Sigma_{i \neq s, r}$ = sum over all components except steam, and the non-volatile components.
$\Theta = L/F$; Θ_a = an assumed value of Θ; Θ_r = the desired root of the flash equation, equation (11).

Not Starry Eyed

To The Editor:

Your choice of authors in the recent "Special Computer Report" (February PR) was excellent. The papers on digital computers particularly were written from a down-to-earth viewpoint which was a refreshing change from the starry eyed "magic brain" type of writing.

As a problem analyst and leader of a group of programmers, I think the digital computer articles are of value in the sense that our "clients" may read them and so gain a better understanding of what we are doing for them.

Further articles on specific problems solved with digital computers should include flow charts or block diagrams of the machine program.

Socony Mobil Laboratories
Paulsboro, N. J.

J. S. Hicks

Continued on Page 91

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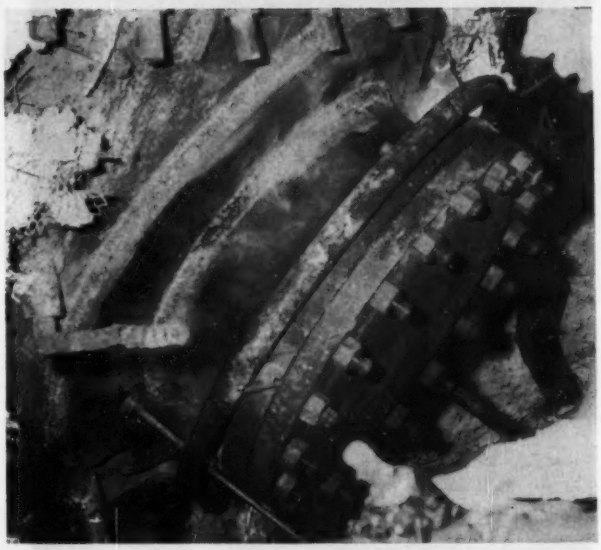

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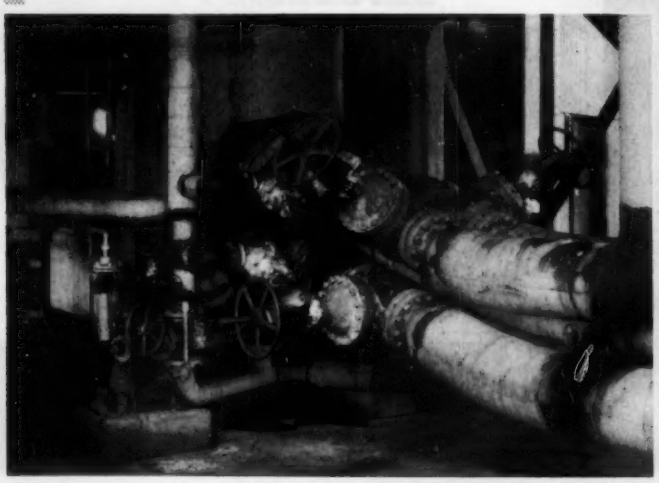

Here is the kind of hot service where MOLYKOTE Lubricants really pay off! Use it on flange studs, bonnet studs, valve stem and threads, gaskets, valve seat insert threads and sliding or press fits. MOLYKOTE works where nothing else will!

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(Continued)

Flame Arresters— Pro and Con

To the Editor:

On Page 100 of the February 1957 issue of Petroleum Refiner begins Part 2, "How to Prevent Crude Oil Tank Fires," of J. L. Risinger's series "Safety and Fire Prevention." Because one section of this article entitled "Proper Use of Flame Arresters and Vents," and a caption under a photograph of conservation vent valve are erroneous, your readers have been seriously misled.

This article states: "Flame arresters are not required and have no purpose on an approved conservation vent." I submit that there are no "approved conservation vents" by any authority or laboratory recognized by industry for establishing such facts. The Underwriters' Laboratories, as a result of exhaustive tests over many, many years, officially state: "Vent valves are not regarded as providing the proper protection against fire and explosion."

Referring to vents for storage tanks, the Associated Factory Mutual Laboratories state: "This type of arrester is intended for installation at or near the end of vent pipes attached to flammable liquid storage tanks, to prevent an outside flame from entering the tank through this opening. They may or may not be equipped with automatic conservation vent valves designed to minimize vapor loss due to evaporation. The arresting elements consist of fine mesh wire screens, bar or sheet grids which act as cooling surfaces to absorb the heat of the flame. Flame arresters should be provided at vents on (a) all tanks containing liquids with flash points below 110 F., and (b), on above-ground tanks containing liquids with flash points higher than 110 F. if they are close to combustible materials or other tanks containing liquids with flash points below 100 F. The size of the flame arrester should meet the requirements for approved venting of storage tanks."

All insurance underwriters recognize the findings of these two laboratories and charge an insurance premium penalty which is more than enough to amortize the cost of installation in two or three years, and to pay for regular and proper inspection and maintenance, to make it interesting for an owner of storage tanks containing volatile products to install them as an important safety measure.

Practically every time a low pressure (commonly referred to as an atmospheric type) tank containing volatile petroleum products is emptied, its vapor is of combustible mixture. Every time a vent valve opens to exhale, there is a point in each closing cycle due to "blow-down" characteristics of vent valves, at which the velocity of gas through it is less than the propagation of flame (15 linear feet per second, or, approximately ½ ounce per square inch velocity pressure). If exhaled combustible vapor is ignited at the vent, flame will pass up stream, against the gas flow, into the tank every time unless there is a flame arrester. Conservation vent valves are not flame arresters.

The NFPA Flammable Liquids Code No. 30 of May, 1957, Paragraph 213 VENTS, Sub-paragraph 2131 states: "Tanks storing Class I and Class II flammable liquids shall be equipped where

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Open Gravity Distribution
so simple, so logical, so effective

Water seeks a lower level. Hot water distribution on Marley Cross-Flow cooling towers is just that simple, and the advantages of this fundamentally sound system are many.

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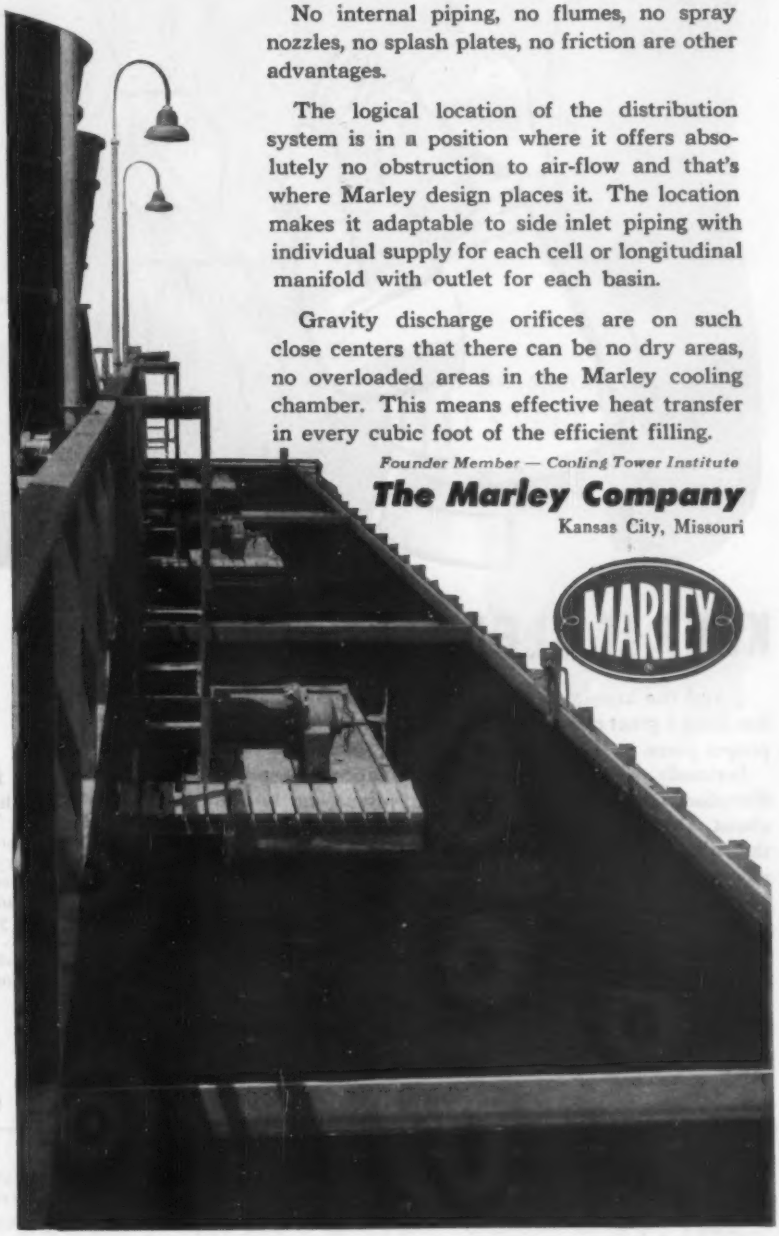

No internal piping, no flumes, no spray nozzles, no splash plates, no friction are other advantages.

The logical location of the distribution system is in a position where it offers absolutely no obstruction to air-flow and that's where Marley design places it. The location makes it adaptable to side inlet piping with individual supply for each cell or longitudinal manifold with outlet for each basin.

Gravity discharge orifices are on such close centers that there can be no dry areas, no overloaded areas in the Marley cooling chamber. This means effective heat transfer in every cubic foot of the efficient filling.

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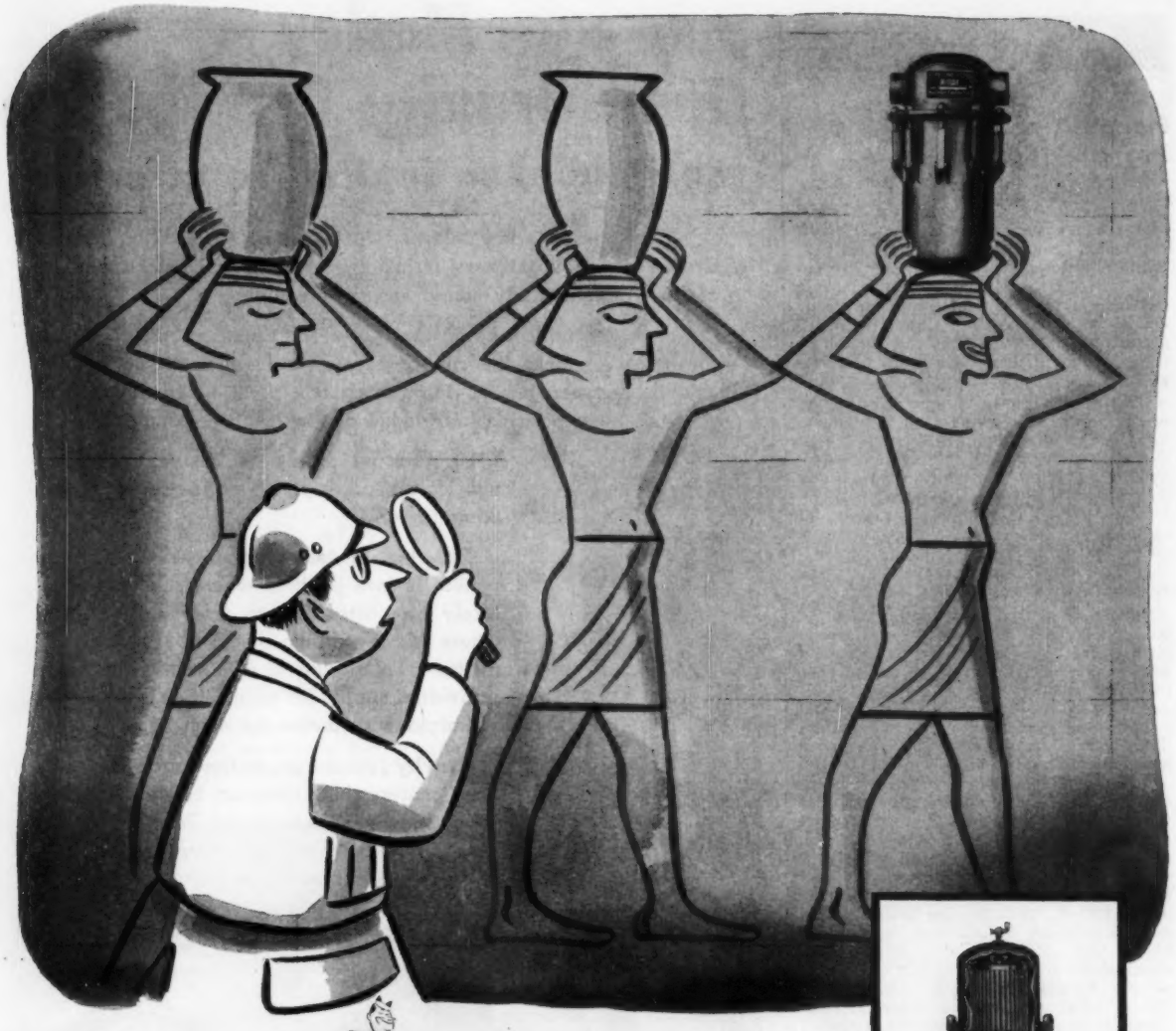

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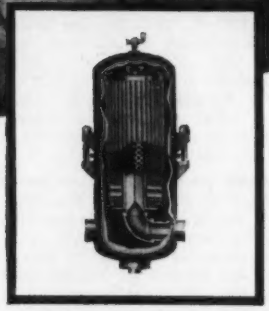

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(Continued)

practical with either venting devices which shall be normally closed when not under pressure or vacuum, or with approved flame arresters, except that tanks under 2500 gallons capacity for Class I liquids and tanks under 3000 barrels capacity for crude oil in producing areas may have open vents." Obviously, no flame arrester would be required if the vent valve were closed because there would be no opening. Vent valves are mechanical in nature and consequently are not perfect. Inner valves of some types may warp quite badly, and in some types of improperly designed valves, may even hang open. It is when these conservation vent valves are performing their function of venting the tank, and are therefore "open," or, otherwise being held open as just mentioned, that approved or listed flame arresters are important. In my opinion, this phraseology in the NFPA Code needs serious clarification but, even it does not refer to an "approved conservation vent" because there just is no such thing.

The article states: "In no case is a tank required to have both the approved conservation vent and the approved flame arrester." Of course, neither valve nor arrester is required, except possibly by some local ordinance. However, an efficient operator will install a conservation vent valve because it makes him money by conserving gas. Likewise, if an operator is at all safety conscious and the least bit interested in cost of operation, he will install approved or listed flame arresters.

The article states: "Flame arresters on these vents are not required and cannot be justified in the light of oil industry experience." The first part of this sentence has already been discussed. The second part is highly controversial. For 33 years I have traveled oil fields and refineries and have seen and have taken photographs of many cone roof tanks with ballooned roofs and distorted shells as a result of internal fire pressure. I have recently talked with several men of the NFPA group, some of whom agree that flame arresters are not necessary according to statistics of their own organization. Each was with a large company which was a self-insurer, but each admitted that no one was around competent to decide what happened when a tank roof ballooned from internal fire pressure and distorted the tank shell, or, how the tank vapor was ignited . . . but there was a fire inside the tank and no flame arrester in the vent outlet. I have seen ballooned tanks equipped with flame arresters and I have made investigations only to find that pumping speeds were increased, tank service changed to more volatile product, or the vent equipment was undersized in the first place, or was not properly maintained.

Even the NFPA Code states: "Where the liquids stored have flash points in the range of normal summer temperatures, the vapor space above the liquid in the tank will normally contain vapors in the explosive range. On such tanks flame arresters have their most important application." I do not interpret this to mean that they recommend a flame arrester in the vent in order to keep ignited gas from getting out of the tank, but to prevent flame from ignited exhaled gas, when in the combustible range, from entering the tank.

Mr. Risinger states: "They (flame arresters) greatly reduce the venting capac-

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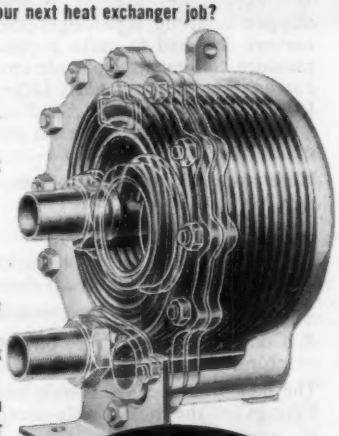

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(Continued)

ity, are difficult to keep from clogging, may cause a tank roof rupture and their cleaning and upkeep presents a problem in any climate." Flame arresters do reduce venting capacity, and so do conservation vent valves, as compared with, for instance, the flow through an open nipple or a frictionless orifice. Proper sizing and maintenance of a flame arrester or a vent valve is a justified engineering problem just as much as the proper sizing of a pump to do a specific job. Shoddy and frequently complete lack of maintenance of venting equipment which protects billions of dollars worth of valuable product is no more excuse for the failure of this equipment for these reasons than would be the failure of a pump through the deliberate neglect of some stupid operator. Flame arresters and vent valves do not wear out from their function, but by corrosion, so they have long life which possibly accounts for their neglect. None-the-less, their importance cannot be over-emphasized.

A photograph (Figure 2) is captioned: "Conservation vent with no flame arrester bank. Flame arresters are not needed on approved conservation vents. They are themselves effective flame arresters, as well as vapor conservation devices."

I would like to emphasize that there are no "approved conservation vents," and that conservation vents are not "effective flame arresters" on low pressure, atmospheric type tanks.

Frank V. Long Sr.
President
The Vapor Recovery Systems Company
Compton, Calif.

From the Author

The question appears to be should those who use venting devices that are normally closed when not under pressure or vacuum be required to purchase and use with them the approved flame arresters? The negative to this question will be covered as briefly as possible.

After the approval by its technical committees The National Fire Protection Association adopted a standard designated as NFPA 30-L, Suggested Ordinance for the Storage Handling and use of Flammable Liquids. From time to time this 30-L has been amended to keep it in step with progress, just as such codes as the National Electric Code and other standards of the NFPA. Actual tests under field conditions and long experience of the oil industry revealed that flame arresters are not needed on storage tank venting devices that are normally closed when not under pressure or vacuum, to prevent the flame from traveling down into the tank. Thus the Flammable Liquids Committee approved—if you please, paragraph 208-01 of 30-L and it was included in the standard after adoption in annual session:

"Tanks storing Class I and Class II flammable liquids shall be equipped where practical with either venting devices which shall be normally closed when not under pressure or vacuum, or with approved flame arresters, except that tanks under 2500 gallons capacity for Class I liquids and tanks under 3000 barrels capacity for crude oil in producing areas may have open vents."

I firmly believe that the use of venting devices that are normally closed when not under pressure or vacuum is the answer to

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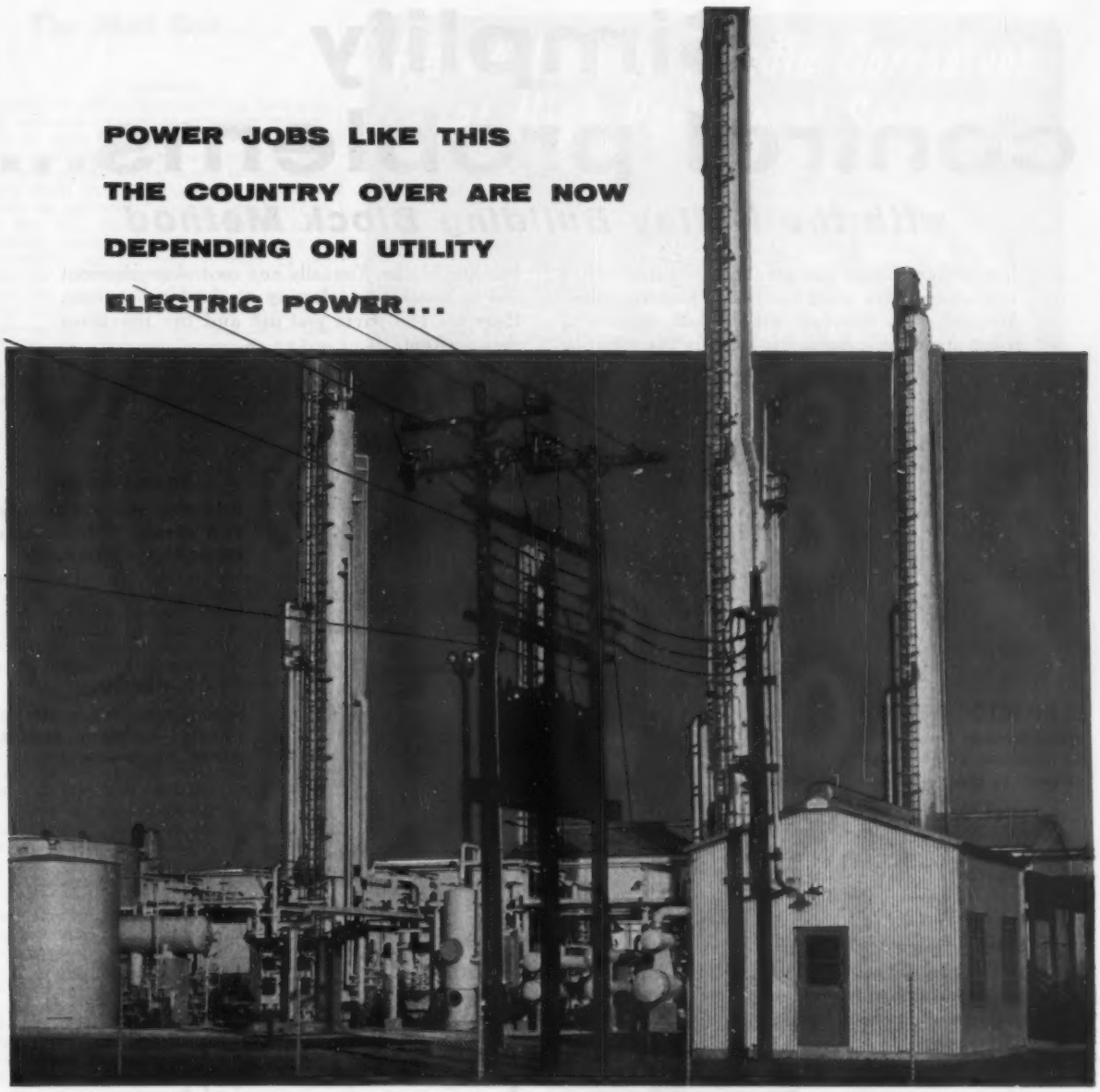

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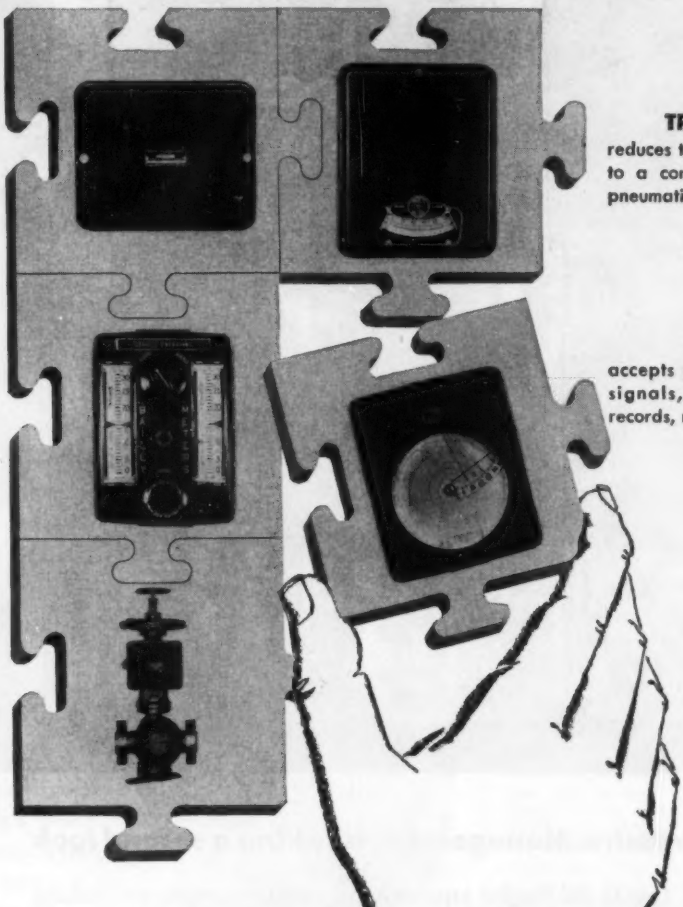
POWER UNIT
is the "muscle" of the system. It performs whatever precise mechanical action is necessary to achieve control.



TRANSMITTER
reduces the measured variable to a common denominator, a pneumatic or electric signal.

RECEIVER
accepts pneumatic or electric signals, indicates and/or records, measurements.

Not all these components are required in every control system. You buy only what *your* system needs. When you change processes or add more automatic control, you can add additional standard components. Sometimes you may want to build a whole new system, re-using some of the existing components and adding other new ones. Spare parts inventory and maintenance training are reduced.

Hear the complete story of the Bailey Building Block System. Find how it can solve your control problems. See your Bailey Engineer or write for more information.

CP-1-1

BAILEY BUILDING BLOCK METHOD

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CHEMICAL AND PETROLEUM DIVISION
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In Canada—Bailey Meter Company Limited, Montreal

RESULTS IN: FLEXIBILITY, SIMPLICITY, ECONOMY

BAILEY METERS

The Mail Box . . .

(Continued)

keeping the flame from traveling back into the tank and causing an explosion in addition to their conservation service. I have been convinced by test and experience that the prevention of the travel of the flame back down into the tank is not dependent alone on the vent closing so completely as to stop this travel but also on its back pressure conditioning the vapor space to saturation and too rich to burn by the time the vent would close. I do not believe that the venting device has to be such that flame will not propagate through it between two explosive mixtures under laboratory test conditions, neither do I advocate open vents on large tanks containing oils with flash-points below 70 F. It is very evident that a vast majority concur or else the standard would not have been adopted by the National Fire Protection Association's over 180 national and regional societies and associations and more than 15,000 individuals, corporations, and organizations included in its membership.

Quoting also from inside cover 30-L NFPA:

"The National Board of Fire Underwriters Standards for Storage, Handling and Use of Flammable Liquids, NBFU Pamphlet 30, contains technical provisions based on and substantially identical with the NFPA suggested ordinance, but differing in form and arrangement."

Again quoting from 30-L NFPA:

"The Underwriters Laboratories Inc. Underwriters Laboratories of Canada and the Factory Mutual Laboratories, test devices and materials for use in accordance with the appropriate standards, and publish lists which are available on request."

These test individual devices and materials for their suitability under these standards. Tests on individual devices and materials not purposed to installation under these standards have no relations to them. These devices and materials are presented by manufacturers and others for tests, they pay for these tests, and none are made except they are requested.

Naturally the manufacturer would turn to these laboratories for tests of his devices and materials as to their suitability under the standards. But if he should attempt to change the standard to the suitability of his devices and materials he would be out of bounds.

May I suggest that these insurance companies and oil companies that carry insurance with them and that pay the additional 10 and 20 percent because flame arresters are not used on "venting devices that shall be normally closed when not under pressure or vacuum" get together on this subject, and tally up the cases in which flames have travelled down through these vents that are normally closed when not under pressure or vacuum and take this into consideration. They can find plenty cases of fire to these vents under field operating conditions. If they find any cases in which flames have travelled down into the tank through these vents and caused an explosion it is more than I have been able to do during the past 20 years.

Maplewood, N. J. J. L. RISINGER

Discussion of timely topics relating to the processing field are invited for this column, a regular feature. Address Editorial Director, Petroleum Refiner, Box 2608, Houston.

CHEMLON YARN PACKING STYLE C-30 Made of TEFLON* FIBER BY "JOHN CRANE"

Chemlon Yarn Style C-30 extra tough packing gives you two important advantages not provided by other types of braided or molded Teflon packing: 1) positive sealing efficiency at high peripheral speeds; 2) cooler running stuffing box under severe service conditions.

Style C-30 can be used to handle the most destructive acids, alkalis or solvents. The excellent thermal properties of Teflon, combined with the softness, resiliency and fluid retentive properties of fine fiber construction, adapt it to high temperature conditions to +300°F. The packing is made firm and dense by means of a special process which eliminates *large* voids.

HERE'S PERFORMANCE PROOF:—Fluid handled: 45% H_2SO_4 (impure) at 170°F.—Operating conditions: 1¼" pump shaft at 1700 rpm. or 555 fpm. peripheral speed. Results: 46 days good service. Previous best service record 7 to 10 days.

Chemlon Yarn Packing Style C-30 is available in spool or coil form, in a wide range of sizes from ⅛" up. *Can be lubricated with Teflon suspensoid or various types of lubricants.*

Send for Bulletin No. P-325. Crane Packing Co., 6420 Oakton St., Morton Grove, Ill., (Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

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JOHN CRANE **CRANE PACKING COMPANY** 38 YEARS INDUSTRIAL PROGRESS

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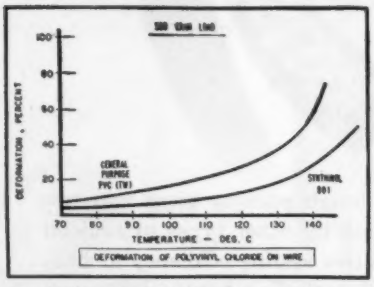
Troubled with wiring failures in your refinery?

If so, consider the record being established by Rome Synthinol 901, a special 90° PVC compound for wire insulation and sheathing. It has helped to solve an impressive list of difficult wiring problems.

Developed by Rome Cable's laboratory and first introduced in 1949, Rome Synthinol 901 has proved by test and actual use to be superior to conventional PVC compounds in the following ways:

a. Suitable for continuous operation at higher temperature (90°C).
b. More stable under severe heat cycling.
c. Suitable for continuous immersion in hot transformer oil.
d. Superior resistance to chemicals and solvents.
e. Greater resistance to heat deformation.



Graph shows heat deformation vs. temperature, and compares Synthinol 901 with conventional PVC compounds. Test run in accordance with Underwriters' Laboratories standard procedure, except for temperature.

The practical value of this compound can best be illustrated by describing a number of actual case histories.

(1) Oil refinery, industrial and chemical plant wiring.

Plant and oil refinery engineers have long used conventional PVC insulations for plant wiring with good results, but too often heat deformation problems arose in warm locations. Since Rome Synthinol 901's superior deformation resistance suggested that it might be the answer to this problem, it was tried and soon became widely used because of its much better service record.

Synthinol 901 also proved to be far superior to .conventional materials for chemical plant wiring where the corrosive action of chemicals and solvents has always been a tough problem. Although polyvinyl chlorides as a class have inherently better resistance to chemicals and solvents than many other materials, some engineers desired even further improvement. One user decided to test a number of samples over a long period by immersing them in various concentrations of acetone, different alkalis, and butyric, propionic, and acetic acids. The results of this careful evaluation showed clearly that, when exposed to these chemicals, Synthinol 901 would last longer than any other PVC tested.

(2) Oil-filled transformers.

Transformer engineers have long sought a cable construction to replace varnished cambric-insulated cable for leads in oil-filled transformers. These leads connect transformer windings and bushings and are constantly immersed in hot oil. One transformer manufacturer, encouraged by successful experience with Synthinol 901 on other applications, undertook a comprehensive study of the possible usefulness of this insulation in lieu of varnished cambric for high-voltage transformer leads. This study extended over a several-year period and proved to those engineers involved that there were at least four reasons for standardizing on Synthinol 901 for this application:

a. There was less sludge in the oil than when VC insulation was used.
b. There was no harmful degradation of the electrical properties of the oil.
c. Conductors insulated with Synthinol 901 ran cooler, permitting a 7% increase in lead cable current rating.
d. The use of Synthinol 901 in lieu of VC would permit substantial dollar savings.

(3) Coil leads.

Many manufacturers of small coils for relays, small transformers, small motors, and electronic components have tried to use PVC insulated lead wires for many years. Typically, these leads are crimped or soldered to the ends of the coil; and the whole coil is then impregnated with varnish or wax and baked as long as 16 hours at temperatures as high as 150° C. The varnish used may be asphaltic, phenolic, alkyd, etc.; and the wax may be paraffin, beeswax, carnauba, or another kind.

PVC insulated lead wires frequently produced serious production problems because of the insulation's tendency to shrink, crack, and stiffen during the impregnation and subsequent baking period. Synthinol 901 was substituted in place of the ordinary PVC insulation and, after nearly eight years of wide usage, not a single case of shrinkage, cracking, or stiffening of insulation involving Synthinol 901 has been brought to our attention.

These case histories describe just a few of the applications for which Rome's Synthinol 901 has proved especially effective. Perhaps they will suggest other applications in your own area which might also be better handled with Rome Synthinol 901 instead of a conventional PVC compound. If you have a wire or cable problem that might be solved with Rome Synthinol 901, why don't you get in touch with us? Contact your nearest Rome Cable representative for more information—or write to Department 320, Rome Cable Corporation, Rome, N. Y.

ROME CABLE
CORPORATION

A Quick Look at the Industry THIS MONTH

Do Independents Need Government Help? . . . No, says Office of Oil and Gas Director Hugh Stewart—independent refiners are strong and aggressive, need no government assist. Sen. John Sparkman, chairman of Senate Small Business Committee, is far from convinced Stewart is right. Says there is unmistakable evidence independents have "steadily deteriorated" since '45.

Result: Sen. Sparkman has sent letters to several small refining companies asking for comments on Stewart's statements—and ways in which federal government can help independents get proportionate share of burgeoning market. Also, reports on growth since '45 and prospects for future growth are being requested.

Independents may get boost from still another source. Small Business Subcommittee has requested Navy to increase jet fuel set-aside from present 8 million barrels to 14 or 15 million barrels. There is one hitch—independents must offer more product than they have in past (see related story on page 236).

In most recent procurement, small refiners received awards for 9.8 million barrels after making competitive bids on unreserved portion of award. As a result, independents didn't have enough product left to take full advantage of set-aside. They accepted awards for only 2.35 million barrels out of 4 million offered them.

Refining Outlook . . . Excess product stocks continue to plague refiners. At beginning of third quarter (July 1), stocks totaled 509.8 million barrels, up 10.8 percent over year ago. At same time, demand for four major products was up only 2.5 percent. Because of Suez, all-product demand was up 5.4 percent.

Rate of new supply (all oils) averaged about 9.5 million bpd through July. Chase Manhattan Bank says these combined factors indicate a required new supply reduction of 670,000 pbd during third quarter if desired stock level is to be reached by Nov. 1.

Weak gasoline markets in Midwest would be much worse if it weren't for strike-created 265,000 bpd cutback in refinery runs during past three months. Even so, net decline in runs was only 78,000 bpd in July—from 8.05 million bpd when strikes started in May to 7.92 million bpd in mid-July.

Hydrocracking Shows Promise . . . Refiners are still seeking economical way to convert residuum into gasoline stock. Latest method to be tested—cracking in a hydrogen atmosphere—has shown promising results. Researchers in Hungary propose to get more feed stock for use in gas forming processes.

Oil and the Jet Age . . . Two recent rocket developments may create markets for petroleum products:

- Experiments are being run to use structural plastics for rocket housing and hydraulic manifolds.
- One company has developed flexible fuel containing standard GRS rubber plasticized with high proportion of low cost oil. When mixed with ammonium nitrate, this yields propellant which can be extruded into any desired shape at low material cost of 6¢ per pound.

Quick Glance at Washington . . . It actually will be several months before there can be ascertained the full effects of the President's request that companies east of the Rockies reduce their oil imports by 10 percent . . . **Though chances are nil,** Eisenhower again has stressed need to pass natural gas legislation in this session of Congress . . . **Sen. Kefauver's S-11 antitrust pricing bill is** headed for wastebasket, at least for this session—thus, cut-rate prices for gasoline will continue to be legal if given to meet competition . . . **Rather than forbid major oil companies** to own and operate retail stations (divorcement bill), House Small Business Committee favors having majors set equal price to all retailers—stronger antitrust law enforcement by states and federal government . . . **Sen. O'Mahoney's subcommittee** will stick by wording in its report condemning domestic oil company operations; however, it will not be issued until three members of group can submit comments on it.

Can Synthetic Natural Compete? . . . Not if present market conditions continue. With current price of natural rubber running only 9 cents above general purpose synthetic, estimated cost for producing cis-isoprene synthetic natural would be about equal to natural, or 32 cents per pound. Because of huge capital investment needed for plants, it would take total war or extreme increase in price of natural to entice anyone into large scale manufacture.

Poly-butadienes may prove cheaper to make than isoprene type rubbers. But, they are at least four years off. Reason: Stiff competition from natural rubber.

Postings on Octane Race . . . Premium gasoline octanes averaged 98.2 in July—the same as in June. Regular was 0.1 below June, averaging 90.9 octanes.

Announced construction for reforming and alkylation, however, indicates no let up for growing octane level. For example, alkylation capacity announced for construction in '58 is already greater than that scheduled for completion this year.

Latest in Additive Developments . . . Additives are still being studied as means of improving gasoline quality:

- Texas Company announces additive to reduce difficulties caused by rust in aviation gasoline (see related story on page 234).
- Ethyl Corporation has developed an organic manganese compound (AK-33X) which promises to increase power obtained from aviation gasoline by as much as 20 percent.

Good News for Asphalt Makers . . . Asphalt pavement has good chance to re-enter bidding for Air Force runways. Maj. Gen. Walter K. Wilson, Jr. told House investigating committee he is sure he can place flexible pavement in interior portion of runways that will withstand traffic of 228-ton B-52 bombers. Air Force officials still have to be convinced.

Predictions are that mammoth $100 billion highway program will be even larger than first announced. Bill pending in Senate Public Works Committee would lengthen 41,000-mile system another 7000 miles; with completion date extended from 15 to 20 years. Bill won't be considered until next session of Congress.

New Worries for Labor Unions . . . O.C.A.W. feels it has everything to lose—nothing to gain from automation-created personnel shift in refining industry. Between '47 and '56, number of refinery white collar workers increased from 47,800 to 70,100—up 46.7 percent. In same period, production workers dropped from 141,500 to 131,700—down 6.9 percent.

Why O.C.A.W. is worried: With automation, unorganized white collar personnel (engineers and technicians) can take over plant operations when production workers go on strike—white collar workers are hard to organize, thus weakening union's power at the bargaining table.

Cost Hinders Oil Shale Development . . . Large scale commercial production of shale oil is still several years away. Reason: Full-scale operation will require plant able to produce at least 20,000 barrels of shale oil per day, about 100 times the capacity of Union Oil's present plant.

Union spokesmen say a plant of this size will cost about $60 million—could deliver oil via pipe line to Los Angeles at about 1 or 2 cents per gallon more than present day cost of crude.

Denver Research Institute is improving on Swedish process for retorting—says Colorado's shale oil industry will produce a million barrels of oil per day by '70, with total investment of $8 billion.

New Fields Show Promise . . . Fifty-one new U. S. oil fields were opened during June. Most were of about average calibre, but three Rocky Mountain finds appeared to be quite significant and several others showed promise. The top three were: Shell's and Carter's discoveries in San Juan County, Utah, that tested for 1450 barrels and 2330 barrels of 43-gravity oil daily, respectively; and Lewis Bros. and others' Kimble County, Nebraska, strike good for 398 barrels a day.

Pay dirt!
...year after year!

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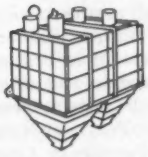
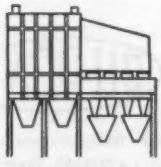


"SF" ELECTRIC PRECIPITATOR



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Buell Cyclone collectors pay off two ways: extra efficiency from the start . . . and extra years of operation, with little if any maintenance. Unique features like Buell's exclusive Shave-off deliver an extra percentage of dust collection efficiency: in nearly all cases, Buell installations pay for themselves in just a few years. And heavy plate construction, scientific proportioning, side entry of dust-laden gases are reasons why they keep on earning for many, many years. For specific details, write for "The Collection and Recovery of Industrial Dusts". Just write Dept. 21-H, Buell Engineering Company, Inc., 70 Pine Street, New York 5, New York.

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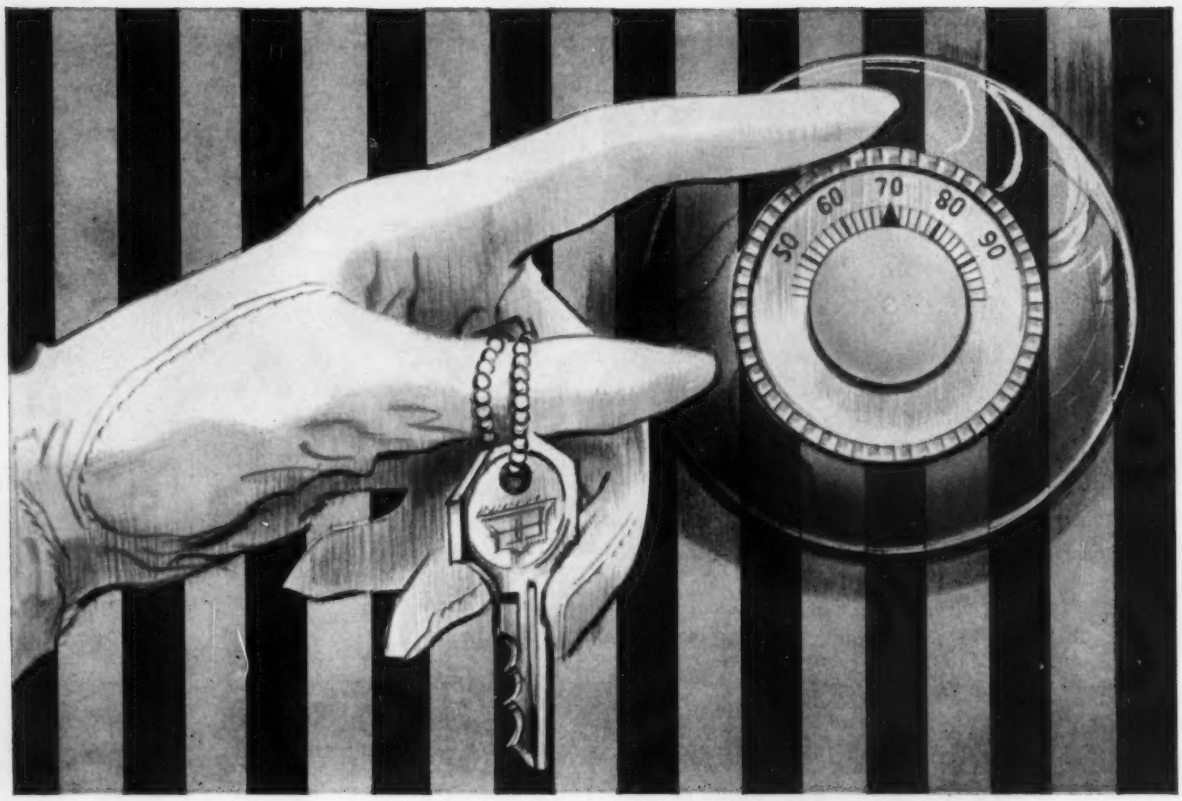

CLEAN-burning...

a heating oil sales feature that can make you extra profits... save you money... increase customer satisfaction

In today's highly competitive fuel oil market, you can gain three distinct advantages by using Du Pont Fuel Oil Additive No. 2 (FOA-2):

1. Win new customers
2. Save money on expensive contract service calls
3. Increase customer satisfaction

Here's why

FOA-2 contributes to clean burning by minimizing deposits in fuel systems. So, by advertising and promoting oils that will stay clean, you will attract new customers who are tired of oil that causes stoppages.

Sludge-free furnace oil means no clogging of filters, strainers, nozzles and other burner parts. Burners stay in adjustment longer and fewer service calls are required.

Dispersant action

Du Pont FOA-2 is also a dispersant and solubilizer. Over a period of time, it reduces pre-formed deposits throughout entire systems.

Ashless

FOA-2 burns completely, without leaving any ash to interfere with the operation of ignition and stack controls. Because of this, it helps reduce chimney deposits and the possibility of puff-backs.

For best results, Du Pont FOA-2 should be added to freshly prepared stocks *at the refinery*. Small amounts are enough to protect most stocks from sludge... insure cleaner burning... reduce deposits in heating systems... prevent nozzle and filter fouling... and *keep* the systems clean.

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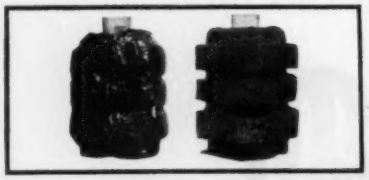

Just look at the difference! Filter on left was used for 90 days with untreated fuel. Filter on right was used for 90 days with same fuel to which FOA-2 had been added.

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The Critics Are At It Again

THE ROAD TO SOCIALISM is being doused with a new coat of oil.

With public opinion holding the oil industry at bay, a few government officials and members of the press are once again firing away with blast after blast of half-truths and untruths. Their words, based in many instances on gross inexperience in industry affairs, are aimed straight at the economic heart of the oil industry.

Unless something is done, the relatively small group of socialism advocates may soon take leading strides toward their goal of federal control.

The need for action has become even more apparent in recent weeks. To give but one example, an eastern newspaper recently published a series of ten feature articles viciously attacking nearly every aspect of the oil industry. The false information was far too voluminous to mention here in its entirety. Following are just three examples:

- "Until the natural gas bill last year, the oil lobby was a tremendous success. Little known to the public, it had put over such things as the 27½-percent tax cut for oil men, the tidelands grab, the sellaway of synthetic rubber plants, the supression of synthetic oil experiments."
- "It has been a long time since the seven major oil companies have competed for markets. Nearly everything is staked out to eliminate competition."
- ". . . Oil's great drive is for the immediate and practically limitless profit; in the process the public may be damned, doomed or delighted."

The articles were injurious and erroneous enough to merit a reply by API President Frank Porter. However, his rebuttal was blunted by the fact that he was allowed inadequate space and then after the series had ended.

The justice of which democracies like to boast—justice that is based on fair and objective evaluation of both sides of a case—could hardly be expected to emerge from such a set of circumstances.

The same situation applies in the case history of Joseph O'Mahoney's Senate subcommittee which recently held a public session to let the press in on a preliminary report that thoroughly lambasted the oil industry. Some statements from that session:

- In no aspect of the oil industry has the monopoly of the few been so all-inclusive as in the case of crude oil pipe lines, which are all but 100-percent owned or controlled by the major oil companies.
- Control over transportation has been found to be the most effective method of controlling the U. S. oil industry.
- Pipe lines have the power of life and death over independent competitors.

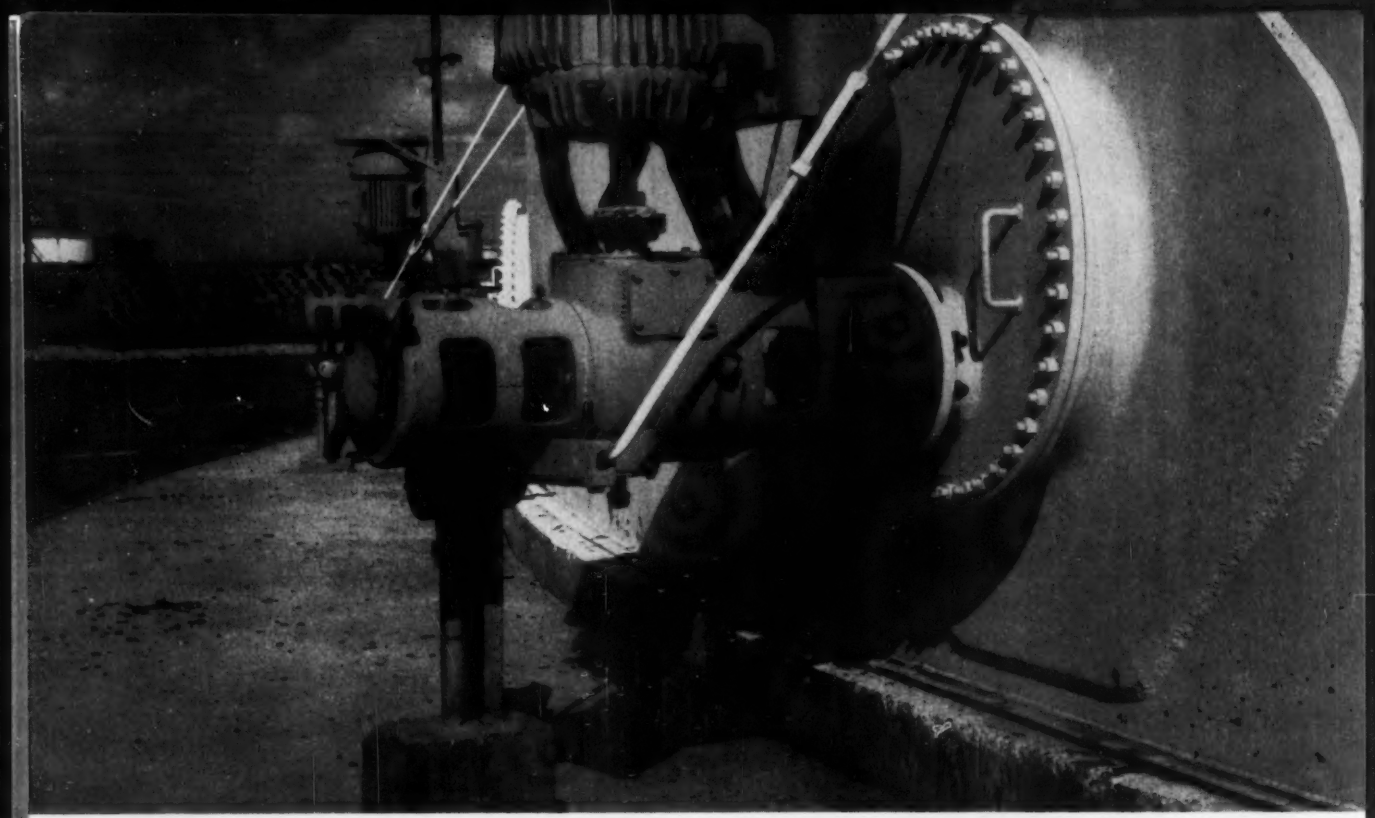
These statements, prepared in conveniently brief form, hit the front pages of newspapers across the nation. Although Senator O'Mahoney said the oil companies were given an opportunity to reply to the charges, no immediate reply was made.

What good would it have done? Oil industry spokesmen, repeatedly, year after year have presented facts and statistics to government investigators and legislators—only to run smack into a stone wall. When handling oil matters, it is difficult for a senator or congressman to act on the actual facts of an issue, particularly when his decisions are governed too often by those whose attitude is molded by faulty information that has been presented by completely inexperienced "experts."

These two recent happenings are cited to illustrate the urgent need for better public understanding of oil industry operations. There are several excellent ways to reach this goal. However, someone—or some industry group—must take the initiative and start the action.

Following are suggestions that would help immeasurably in the oil industry quest for public good will:

1. When controversial issues arise, the industry could present its side to the press in as complete a fashion and just as prominently as its critics. Institutional ads have worked wonders for other industries. More of these from the oil industry might prove helpful.
2. Maintain a more open policy toward the press when queried about company operations.
3. Top management should give public relations representatives full support in keeping oil industry employes, stockholders and the public informed about oil's side of controversial issues and critical statements. Industry stockholders and employes alone represent a potential of nearly three million "good will ambassadors" for the oil industry. They could do a tremendous job for oil by speaking up in behalf of the industry when talking to friends or neigh-



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How Sinclair stops leakage, saves work

blending 150,000 bbl. of product in 6 hours

You can see, in this unretouched picture, how clean and safe Sinclair Refining Company keeps this product-blending operation, with the help of LIGHTNIN Mixers.

Tanks like this at Sinclair's Houston refinery hold 150,000 bbl. of finished gasoline. LIGHTNIN Mixers, three to a tank, blend the gasoline to full uniformity in just six hours. Not a drop gets through the LIGHTNIN rotary shaft seals!

Never need repacking

Even more significant is the saving—in time and maintenance cost—that Sinclair makes with mechanical seal-equipped LIGHTNINS. They *never* need to be repacked, *never* need shaft seal adjustment!

These LIGHTNINS have been in operation one year. "Maintenance requirements? Negligible!" say Sinclair's refining people.

You can save as much as 60% on big tank mixer maintenance with this newest LIGHTNIN feature. Year after year, you get dependable sealing, end stuffing-box repacking and adjustment for good.

Fast, easy replacement

And for the first time ever on side entering mixers, you can replace this seal *in a jiffy* if you ever have to!

Even under a full head of liquid in the tank, the seal-change job takes only minutes. No need to dismantle or remove the mixer from the tank. No special skill needed, either—it's a one-man, one-wrench job!

Available on all LIGHTNIN Side Entering Mixers, the LIGHTNIN seal cartridge is a unit assembly, easy to stock as a replacement or quickly obtainable in all sizes and materials for the simplest or toughest mixing conditions.

How much can *you* save? Your LIGHTNIN Mixer representative can give you the full story. Call him today—he's listed in Refinery Catalog. Or send the coupon for 8-page illustrated bulletin on LIGHTNIN seals and catalog information on LIGHTNIN Mixers.

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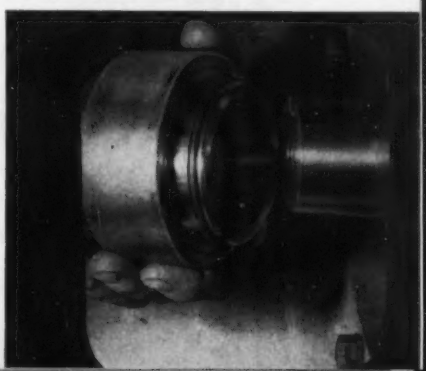

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bors. Some might even voluntarily express their views to senators and congressmen.

4. API could maintain a well informed staff in Washington to cooperate fully with government officials who are sincere in their efforts to consider both sides of controversial issues—to have accurate and complete statistics at their fingertips when needed—to correct erroneous blasts against the oil industry.

In short, petroleum leaders should ever be alert and aggressive to checkmate the mouthings of misguided propagandists whose lodestar, obviously, is complete government control of the oil industry.

Gasoline Stocks Improving

THE NATION'S REFINERS have done a very creditable job of tailoring their operations to better fit needs for their products. Recent weeks have seen a very marked improvement. Results of a downward refining adjustment have been better relationship of products stocks with current usage. That is particularly true of gasoline supplies, which are now, for the first time in several years, below the previous year's volume. Distillate fuel oil inventories are perhaps too high, but at least the rate of their growth has been stunted.

Heavy gasoline consumption usually follows the closing of schools about the start of June, but this year for some unexplained reason the mobile American public did not get started until recent weeks. Gasoline usuage is now hitting expected rates. Coupled with refiners' voluntary easing of throughput rates, this upturn in gasoline demand has done a good job in drawing down supplies.

For the first time in more than two years, motor fuel inventories are actually below the previous year's supply. On July 19, the API reported U. S. gasoline stocks amounting to 178,267,000 barrels, a drop of 85,000 barrels from the year-before level. A month earlier, these stocks had been 8,000,000 barrels more than in 1956, and two months earlier the excess had been 9,500,000 barrels.

The foregoing does not tell the full gasoline story, for the most serious over-supply conditions exist on the West Coast. Excluding the western supplies, the rest of the nation is in a considerably better supply situation. East of the Rockies' gasoline stocks amount to only 152,849,000 barrels, and these are almost 2,600,000 barrels less than the 155,448,000 barrels that were in the same tanks a year ago.

Distillate fuel oil stocks are still on the high side, but for the past month their growth has been held to slightly less than occurred in the same period of 1956. On July 19, these inventories totaled 129,798,000 barrels, which was 21,100,000 barrels more than was in tanks a year earlier. A month earlier, although they were of lesser volume, distillate stocks topped year-before levels by 22,500,000 barrels.

A Memo to Moscow

Dear Mr. Khrushchev:

We just finished reading in the paper about your recent propaganda trip to Czechoslovakia. Of particular interest were your comments to the cheering crowds that in a few short years the Soviet Union will be out-producing the United States.

Obviously, Mr. Khrushchev you need to be told a few facts of life—American life.

For one thing, we didn't reach our present rate of production because someone gave us a quota. It took 181 years—but it was done in an atmosphere of free enterprise with a promise of a better life ahead. Just what incentive are you giving your people to progress Mr. Khrushchev?

Another fact which may interest you is that last year the U. S. reached a milestone in the history of mankind. For the first time in this country—or any other country—we had more people providing services than were producing goods. And at the same time, American production was higher than ever before.

It's not hard to see the point we're making is it, Mr. Khrushchev? Even with your Communistic slant on life you can appreciate that this tremendous increase in services would not have been possible without individual incomes to afford them. On the other hand, however, it is probably difficult for you to comprehend how so many people were able to leave production jobs to start offering services.

It all comes back to the one factor we like to keep tossing at you—American freedom to compete. Competition produced our rapid advances in technology. Competition produced our present utilization of power, resulting in fewer people doing less work, yet producing much more. In short, a higher standard of living than your people will be able to enjoy for generations to come.

To give you an example of what we mean Mr. Khrushchev, did you know that every person in the U. S. consumes an average of 815 gallons of oil products every year? You can compare this with the 100 gallons per year per person in your country (most of which is used for industry and defense)—and the scant one gallon per year used by each of your comrades in Communist China.

Of course, before your people can consume oil products at the U. S. rate, you must first make it possible for them to buy cars, gas stoves, and modern heating facilities.

All of which leads to one final question, Mr. Khrushchev. If you do accomplish the impossible and are able to match our rate of production, who will be left to enjoy the products? The souls of the millions you purge and work to death to reach your quota? Or will you then haul back the untold numbers who have been sent to Siberia?

Ethyl Research Performance of Today's

by T. W. Warren

Director, Refinery Technology, Ethyl Corporation Research Laboratories

A premium fuel being road tested in one of Ethyl's controlled-weather rooms that duplicates road conditions exactly.

Reports on Premium Fuels

NINETY-ONE premium gasolines and 12 third-grade super-premium fuels have been tested on the road and in the laboratory in a research program recently completed by Ethyl's Detroit Research Laboratories.

The results of this investigation have been published in a 140-page report entitled "Antiknock Behavior of Premium Motor Fuels, 1957", now available to all companies in the Oil and Automotive Industries.

The fuels tested were submitted by 83 refineries of 48 American companies. These refineries produce 75 per cent of the motor fuel in the United States. Seven Canadian companies, producing an appreciable percentage of Canada's gasoline needs, also submitted fuel samples for testing.

Each Gasoline Tested 32 Times

Five 1957 cars normally requiring premium fuels, and three cars equipped with experimental 11 to 1 compression-ratio engines were used in the tests. A minimum of two Modified Uniontown and two Modified Borderline ratings were obtained for each gasoline in each car, a total of at least 32 road ratings for each fuel sample.

Extensive laboratory data, including determinations of tetraethyllead susceptibility, hydrocarbon type, and bromine number, were also obtained and are included in the report.

Test Results Point to Future Gasoline Developments

The broad sampling of premium fuels tested gave an accurate picture of today's premium gasolines and how they perform in the cars of today and in the higher compression engines of tomorrow. A complete analysis of all the test data led to the following conclusions affecting refining economics:

1. Sensitivity (the difference between Research and Motor octane number) often is an unreliable measure of road performance through the normal speed range.

2. Research and Motor octane numbers can be used to predict road performance at low speeds but are less reliable at intermediate and high speeds.

3. At higher speeds, road performance increases when the aromatic content of the gasoline is increased.

The 103 premium and super-premium gasolines in these drums were tested for Ethyl Corporation's 1957 premium fuel survey. This is the fifth premium survey conducted by Ethyl since 1946.

An important by-product of this program was the development of a system for calculating the road octane number of a gasoline. This development will permit individual refiners to determine the "road octane number" of their gasoline blends using the results of simple laboratory tests.

How Ethyl Research is helping you

Since World War II, Ethyl Corporation has investigated the laboratory and road performance of premium-grade gasolines in 1946, 1949, 1951 and 1954. During this period, the number of fuels analyzed has increased from 12 gasolines in 1946, to 63 in 1954 and 103 in 1957.

"Antiknock Behavior of Premium Motor Fuels, 1957" is one more example of Ethyl's continuing service to the Oil Industry. Copies can be obtained from your Ethyl Representative or by writing Ethyl Corporation, 100 Park Avenue, New York 17, N. Y.

ETHYL CORPORATION
New York 17, N. Y.

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

RESEARCH . ABORATORIES
1600 W. Eight Mile Road, Ferndale 20, Mich.
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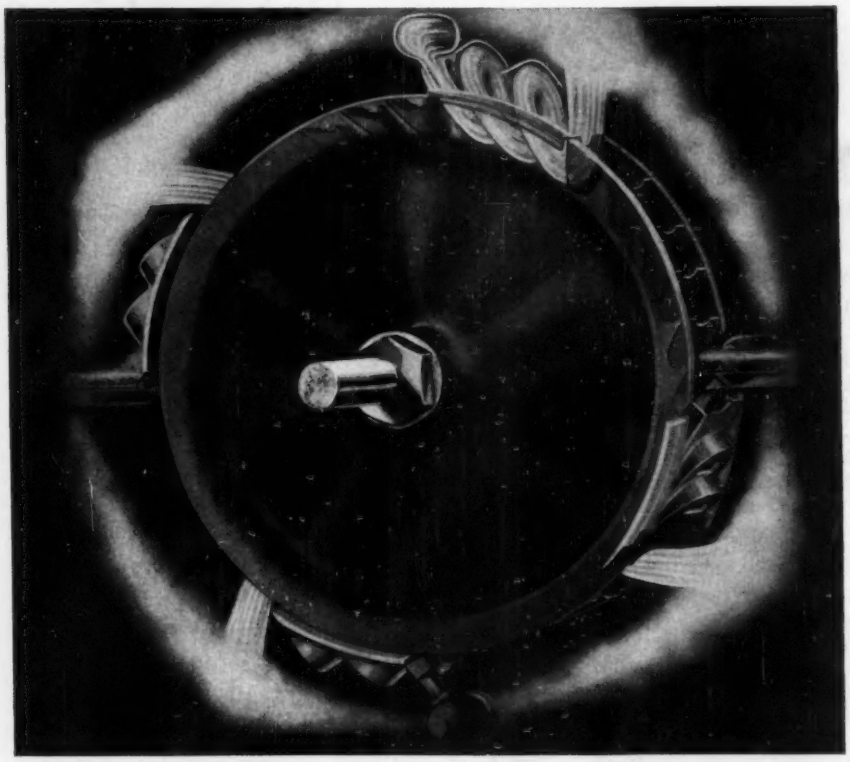
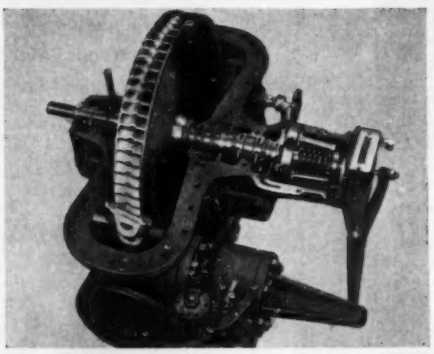
For more data on advertised products, use Readers' Service Cards, last page.

TURBINE BLADES CAN'T FOUL!



The Terry solid-wheel turbine is of the impulse, helical flow type. The steam issues from an expanding nozzle at high velocity and enters the wheel bucket where its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is returned to the wheel several times until practically all of the energy has been utilized. This principle makes possible the efficient use of steam in a single-piece, almost indestructible wheel.



Terry solid-wheel design permits large clearances

In the Terry solid-wheel turbine, the steam enters the buckets in a direction at right angles to the shaft, as shown above. This design eliminates the need for close clearances and provides positive blade protection.

The blades cannot foul. There is a one inch clearance on either side of the wheel. In addition, projecting rims on each side of the buckets prevent damage to the blades even though external thrust should move the wheel.

This is only one of the many advantages of Terry solid-wheel turbines. Write for complete details. Ask for a copy of bulletin S-116.

TERRY

TT-1206

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

For more data on advertised products, use Readers' Service Cards, last page.

THEY HELPED PLAN THIS SPECIAL REPORT: To present you, our reader, with the latest information available on turbines, we asked these industry experts' advice on what our authors should cover. Attending the conference were, left to right: Melvin Noack, Magnolia Petroleum Company; C. R. Apitz, Clark Brothers Company; Vern Thomas, the Lummus Company, and R. C. Steinhoff, Sinclair Refining Company.*

a Special Report on . . .

Turbines

Not all turbines are being developed for modern aircraft. Industrial turbine uses are expanding. So are turbine designs with such recent introductions as the industrial gas turbine and free-piston gasifier. Steam turbine designs have also been expanding with noticeable increases in speeds and initial steam conditions. How can these designs be incorporated into your processes? How can you evaluate which drive to use? Answers to these and other questions prompted this Special Report. It's written to present some unusual considerations that the engineer should make when selecting a turbine drive.

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*The attendance by executives, engineers, superintendents or other employes of oil companies at these editorial conferences does not constitute an endorsement of the Refiner or any other publication. The fact that these industry leaders are allowed to attend the planning conferences shows the interest which companies have in the planning of sound editorial content for the industry.

Which to Use . . .

Turbine or Motor Drives?

Here are the important factors that the designer should consider when selecting large horsepower, high-speed prime movers.

H. C. Mayo and R. E. Daze
The M. W. Kellogg Company, New York

TODAY, NEW refining and petrochemical plants are being built on an ever-increasing scale. As these new process units become larger and larger in size, their steam and power requirements reach staggering proportions. Process units, such as ethylene, butadiene, ammonia, catalytic cracking, and catalytic reforming, to name but a few, require large amounts of power, ranging anywhere from 2000 to more than 30,000 installed horsepower, the major consumers being normally the compressor drivers.

This article will discuss the selection of large-horsepower, high-speed rotating prime movers for refinery and petrochemical applications in the 2000-hp to 15,000-hp range, as used for driving centrifugal and axial compressors. The presentation will cover the steam turbine, electric motor, and combustion gas turbine, as well as one of the newest contenders among industrial drivers, the free-piston gasifier with expansion turbine.

SELECTING THE DRIVER

Horsepower Range. Steam turbines are commercially available in numerous horsepower sizes. Combustion gas turbines and free-piston gasifiers with expansion turbines are available only in limited standard sizes. There are many sizes of electric motors, and the increments of horsepower are reasonably small, so that the load can be matched without appreciable excess horsepower.

Combustion gas turbines are available up to 30,000 hp. They are given NEMA horsepower ratings—i.e., rated at 80 F and 1000 feet altitude, with little inlet or exhaust restrictions. The actual site conditions are usually quite different from the NEMA conditions. A higher ambient temperature, inlet and outlet duct losses, and/or a higher altitude, all tend to change the horsepower output rating of the combustion gas turbine. The horsepower increment between frame sizes is relatively large. In order to match the load to the driver size, consideration should be given to having two or more compressor services arranged for drive-through, with one common driver.

The free-piston gasifiers are individually of small size (nominal rating = 1000 hp per gasifier), and can be combined in multiple assemblies, to make up the required horsepower.

Speed Range. Steam turbines are available in a wide range of speeds for direct drive to the load compressor. Electric motors, expansion turbines, and combustion gas turbines, are limited to standard speeds. Hence, it is usually necessary to use a gear, in order to meet the compressor speed requirements.

Control. With steam turbines and expansion turbines, capacity control of the compressor is normally accomplished by variation of the turbine speed. The horsepower of the single-shaft gas turbine drops off very rapidly with a reduction in speed, so that it is the usual practice to operate the gas turbine at constant speed. The two-shaft gas turbine has a range of speed control comparable to a steam turbine. With constant-speed electric motors, compressor capacity regulation is usually obtained by throttling the suction of the compressor by means of a blast gage or suction damper. If operation of the motor drive at part load is contemplated for any extended period of time, then consideration should be given to variable inlet guide vanes, or the incorporation of a power recovery wheel into the centrifugal compressor. These features will reduce the part-load power costs from 5 to 15 percent, by maintaining good efficiencies at partial loads. In the case of the axial compressor, movable stator blades can be incorporated in the compressor design, to achieve good efficiencies at part loads. Adjustable speed control of motor drives is possible, but expensive.

Installation Environment. In line with today's trend toward "outdoor installations," steam turbines and electric motors are commercially available with special weather-protection features, making them suitable for complete outdoor installations. For effective supervision and servicing, combustion gas turbines and free-piston gasifiers with expansion turbines are usually provided with some minimum protection, such as a roof and partial side-walls. The exact type of housing depends upon local site-conditions.

If the process area is hazardous or semi-hazardous, according to NEMA classifications, then suitable precautions must be taken to make the electrical equipment explosion-proof by means of special enclosures, or by pressuring with air or inert gas.

Consider Existing Facilities. If the driver is to be installed in an existing plant, consideration should be given to making full use of the existing facilities, to minimize new capital expenditure. If the existing facilities are already being used to the limit, such as the boiler plant being fully utilized, then a non-steam driver may be dictated. On the other hand, if large amounts of low-pressure steam are required, then a high-pressure boiler with a "topping turbine" drive may be desirable.

RELIABILITY

Driver Reliability. Many years of operating experience in all types of applications have proven the reliability of steam turbine and electric motor drives. In the U. S., combustion gas turbines and free-piston gasifiers with expansion turbines are relatively new in the mechanical drive field. Combustion gas turbines are operating in over 200 industrial and utility installations, with present indications of an increasing rate of acceptance as large-horsepower drivers. To date, no industrial application of the free-piston gasifier-expansion turbine driver has been made in the United States. In Europe, however, over 94 operating free-piston gasifiers have been installed. Preliminary indications are that their reliability is acceptable for industrial applications.[1, 2, 3, 4]

Energy Source Reliability. The reliability of the energy source depends primarily on the local plant conditions. In general, industrial steam plants have excellent service factors. However, the reserve or overload capacity of the boiler plant must be sufficient to supply steam to the process units during repairs and/or inspection of any one boiler. The continuity of electric power reflects the service record and capacity of the local utility, and depends on the electrical facilities of the individual plant, as provided by the utility and the customer.

Dual feeders from independent sources, with automatic switch-over and duplicate or looped distribution lines within the plant represent the ultimate of assurance against power interruptions.

The supply of natural gas is usually independent of transportation and weather. However, there may be seasonal variations in the supply pressure. In common with all rail and/or water-transported fuels, the reliability of liquid fuels depends on the user having adequate storage capacity.

ECONOMICS

Operating Costs. Operating costs involve a careful and detailed consideration of the expenditures for fuel, supervision, operating and maintenance labor, fixed charges, and depreciation. Fuel is usually the major cost item, not only of the operating expenses, but also of the cost of production; and therefore merits careful study, to assure an optimum selection

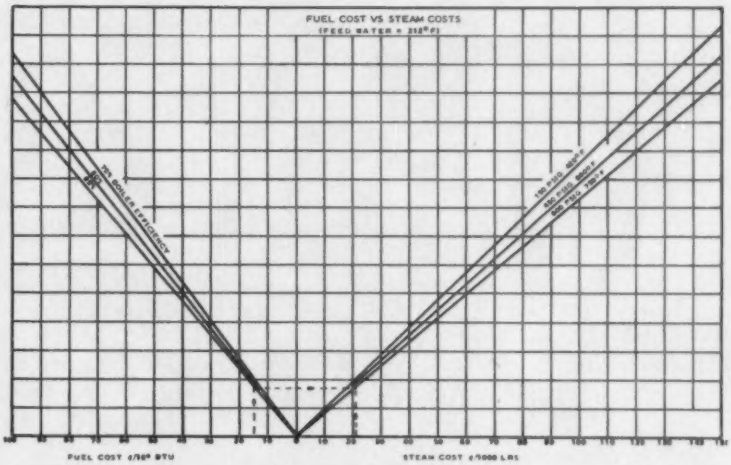

FIGURE 1—If the designer knows the fuel cost, boiler efficiency and operating pressure, he can easily determine the steam cost.

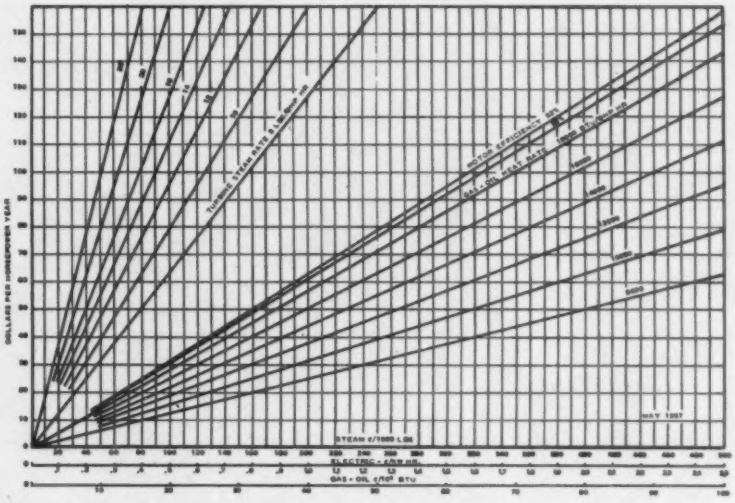

FIGURE 2—Compare various fuel costs when operating at typical fuel rates.

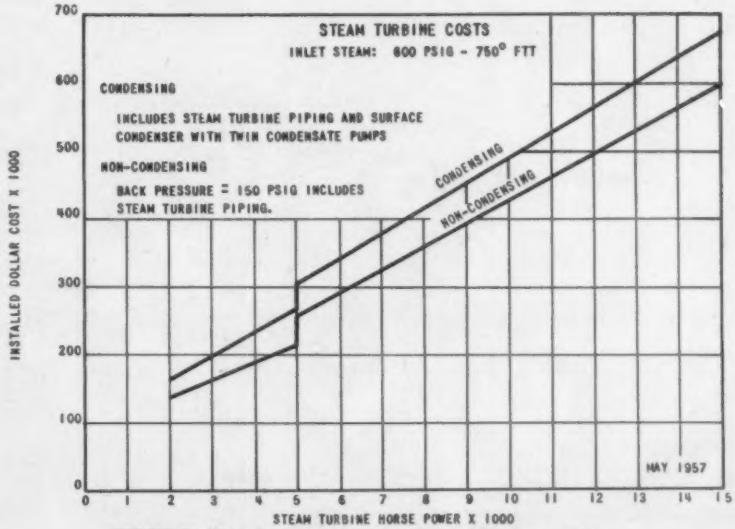
STEAM TURBINE COSTS
INLET STEAM: 600 PSIG - 750° FTT
CONDENSING
INCLUDES STEAM TURBINE PIPING AND SURFACE CONDENSER WITH TWIN CONDENSATE PUMPS
NON-CONDENSING
BACK PRESSURE = 150 PSIG INCLUDES STEAM TURBINE PIPING.
CONDENSING
NON-CONDENSING
INSTALLED DOLLAR COST X 1000
STEAM TURBINE HORSE POWER X 1000
MAY 1957

FIGURE 3—This chart gives investment costs for steam turbines.

for minimum power cost. The cost of fuel energy varies widely, depending on the geographical location of the plant, and on market conditions. Table 1 lists typical costs for electric power, natural gas, and Bunker "C" fuel oil, for typical cities in the U. S. and Canada.

TABLE 1
Cost of Electricity, Gas, and Fuel Oil in Various Cities

LOCATION	Electric Cents per KWHR*	Gas Cents per Million BTU	No. 6 Fuel Oil Dollars per Bbl.
Denver, Colorado	.754	22.4	2.50
New York, New York	1.333	134.0	3.20
Philadelphia, Penn.	.927	....	3.20
Los Angeles, Calif.	.705	....	....
San Francisco, Calif.	.84	31	2.90
Montreal, Canada	.53	157	4.05
Amarillo, Texas	.85	19.0	....
Wichita, Kansas	.758	....	3.10
Toledo, Ohio	.955	40	3.67
Newark, N. J.	.913	....	3.20
Winnipeg, Man., Canada	1.00	44	3.12
Minneapolis, Minn.	.92	40	4.20
Houston, Texas	.55	....	....
Toronto, Ont., Canada	.55	85	....
Edmonton, Alberta, Canada	.683	13.1	2.36
New Orleans, La.	.65	13–18	2.75–3.15

* Based on 5000 KW Load 90% P.F. & 7500 hours annual use.

Steam is normally generated from solid fuel, natural gas, or Bunker "C" fuel oil, used singly or in combination. Figure 1 provides a convenient association of fuel cost, boiler efficiency and the equivalent heat cost of steam for conventional steam pressures and total temperatures.

To resolve the cost of alternate energy sources for a given location, Figure 2 has been prepared. This chart provides a rapid comparison in dollars per horsepower year (8000 hours) for various fuel costs and typical fuel rates or efficiencies.

The heat rate of the simple-cycle combustion gas turbine is comparatively high. However, the over-all fuel efficiency of the combustion gas turbine can be increased if the waste heat in the exhaust gases is recovered. One simple method of waste heat recovery is to generate process steam. Utilizing the heat in the exhaust gases cuts down the stack losses to atmosphere, thereby achieving a greater overall efficiency. There are also other methods for utilizing the heat in the exhaust gases: such as exchanging it against a process stream, or by using the hot gases (still high in oxygen content) as heated combustion air for a catalytic cracking CO boiler, power boiler, or process furnace.

It should be noted that the free-piston gasifier can only burn liquid fuel oils, such as No. 6 and Bunker "C".

Investment Costs. To facilitate the cost comparison of the various types of drivers, several charts have been prepared for estimating the approximate installed cost, including associated equipment. These charts are:

Figure 3. Steam turbine costs.

a. Condensing w/surface condenser

b. Non-condensing

Figure 4. Electric motor costs w/ speed-increasing gear and starting equipment.

Figure 5. Cooling tower costs w/ pumps.

Figure 6. Steam boiler costs

Figure 7. Gas turbine costs

Figure 8. Cost of free-piston gasifier w/expansion turbine

Most of the free-piston gasifiers to date have been manufactured in Europe. However, a U. S. corporation has concluded a license agreement to manufacture free-piston gasifiers with a nominal rating of 1000 hp per gasifier. Since there is no commercial precedent in the U. S. for a commercial free-piston gasifier, the cost of the first units may be relatively high. If the market demand materializes, it is expected eventually that the cost will drop to the point where free-piston gasifiers will be competitive with diesels and oil-burning gas turbines.

Other Costs. Due to the economic climate of the post-world-War-II era, initial cost has been a dominating factor in driver selection. Emphasis has been placed on the investment cost of the operating facilities, rather than on operating costs. Amortization costs have been greatly affected by governmental tax write-off edicts. The goal of equipment engineering is to achieve a balance of these three basic economic influences, namely investment cost, operating cost, and amortization costs.

This presentation is necessarily restricted to investment and operating costs, since amortization constitutes a separate subject, which cannot be adequately treated in an article of this length.

Illustrative Example. The aforegoing general observations may be clari-

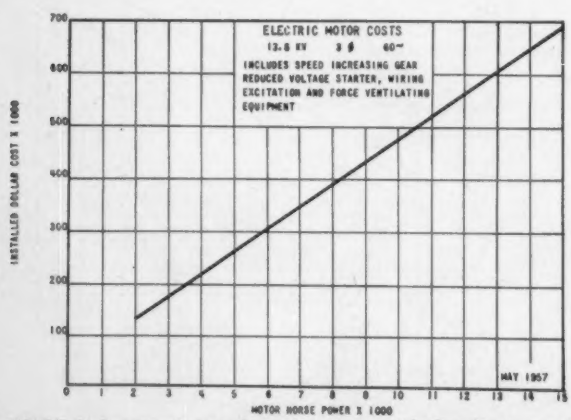
ELECTRIC MOTOR COSTS
INCLUDES SPEED INCREASING GEAR REDUCED VOLTAGE STARTER, WIRING EXCITATION AND FORCE VENTILATING EQUIPMENT
INSTALLED DOLLAR COST X 1000
MOTOR HORSE POWER X 1000
MAY 1957

FIGURE 4—Investment costs for motors is a straight line function and includes speed-increasing gear and starting equipment.

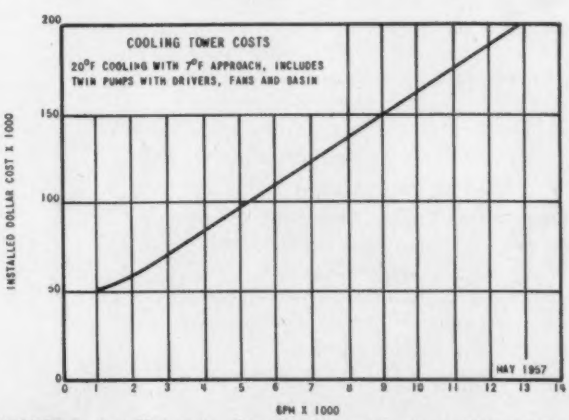
COOLING TOWER COSTS
20°F COOLING WITH 7°F APPROACH, INCLUDES TWIN PUMPS WITH DRIVERS, FANS AND BASIN
INSTALLED DOLLAR COST X 1000
GPM X 1000
MAY 1957

FIGURE 5—Installed costs of cooling towers is given which includes twin pumps with drivers, fans and basin.

fied and the use of the accompanying charts illustrated, by a broad general example.

Let us investigate the selection of a driver for a centrifugal compressor application, in a U. S. Gulf Coast process plant. A typical compressor load requirement would be 6200 hp at 8000 revolutions per minute.

First, consider the suitability and reliability of the various types of drivers. Evaluation of these factors may exclude certain of the alternate drivers, and thus reduce the number of alternate arrangements and estimates which must be prepared and studied. Consideration should be given to the over-all plant heat balance, to obtain the best utilization of the plant fuel input.

In this example, the four types of drives which have been discussed as to generalities will be examined for their specific applications namely:

- Steam turbine
  a. Condensing
  b. Non-condensing
- Electric motor
- Combustion gas turbine
- Free-piston gasifier with expansion turbine

A schematic arrangement for each of these drivers is shown in Figure 9.

The compressor is omitted from economic considerations, since it is common to all cases, and therefore is a fixed quantity in the comparison.

Steam Turbine. To get a complete picture of the investment cost of the steam turbine installation, we must include with it the cost of the steam generator, water treatment, steam piping, surface condenser with condensate pumps, and cooling tower with cooling water pumps, as necessary for the intended operation.

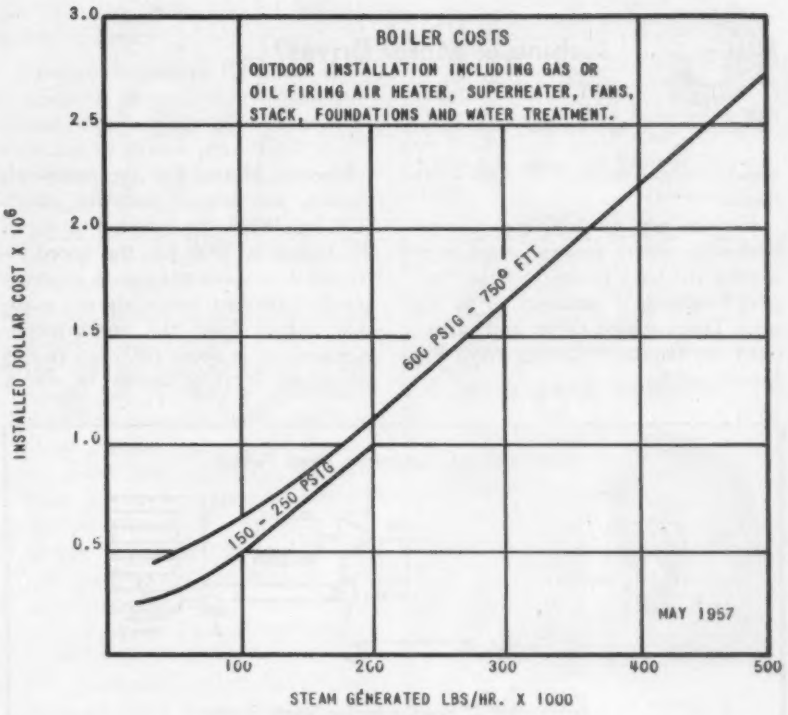

FIGURE 6—Installed boiler costs include gas or oil firing air heater, superheater, fans, stack, foundations and water treatment.

Most process plants require steam for either drivers or process heating. The steam output of the boiler is divided among several loads. High-pressure steam boilers for process plants are normally installed in sizes from 100,000 to 250,000 pounds per hour steam generation. Hence, the boiler cost chargeable to the condensing steam turbine case would be the incremental cost of supplying the 49,500 pounds per hour of 600 psig-750 degree FTT steam required to drive the turbine. For this particular case, we shall take the boiler cost as being the incremental cost of going from a 150,000 pounds per hour steam generator to a 200,000 pounds per hour steam generator.

The installed cost of the steam turbine with surface condenser, cooling tower and steam boiler can be ob-

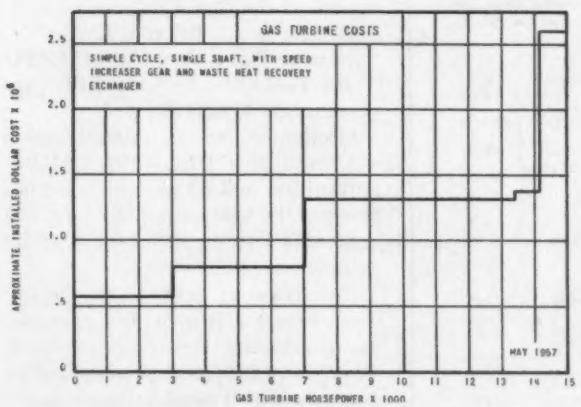
GAS TURBINE COSTS
SIMPLE CYCLE, SINGLE SHAFT, WITH SPEED INCREASER GEAR AND WASTE HEAT RECOVERY EXCHANGER
MAY 1957
APPROXIMATE INSTALLED DOLLAR COST X 10⁶
GAS TURBINE HORSEPOWER X 1000
2.5
2.0
1.5
1.0
.5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

FIGURE 7—Installed cost of a simple cycle turbine includes cost of waste heat recovery system.

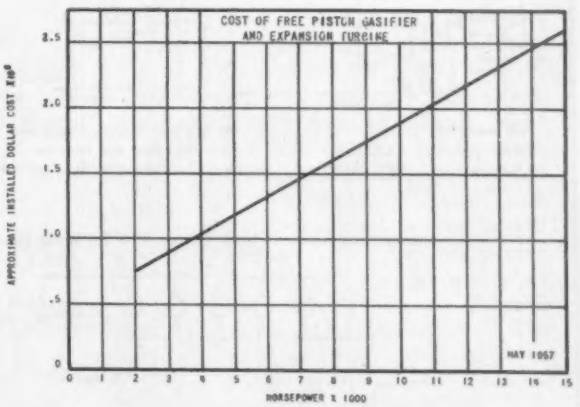

FIGURE 8—Compare the installed cost of the free-piston gassifier and turbine, and the simple cycle, gas turbine, shown in Figure 7.

tained from Figures 3, 5 and 6, respectively.

For the non-condensing steam turbine case, where process steam is required, the back pressure of the "topping" turbine is assumed to be 150 psig. The installed boiler and turbine costs are obtained directly from Figures 6 and 3.

Electric Motor. For the motor alternate, the nearest standard size is 7000 hp. While the nominal rating of the motor is 7000 hp, the speed-increaser gear losses amount to approximately 3 percent; hence, the net available output from the motor-speed-increaser set is about 6800 hp. In this size-range, it is advisable to use a force-ventilated, synchronous motor with speed-increasing gear, twin separate ventilating fans, and twin separate motor-generator sets for excitation.

The installed cost of the motor and associated equipment is obtained from Figure 4.

Combustion Gas Turbine. For this example, we have selected a 7000 hp, NEMA rating, simple cycle, single shaft, combustion gas turbine. Assuming a sea-level installation, ambient air temperature of 95 deg. F., inlet duct and silencer losses of 4 inches water, exhaust duct and waste heat recovery exchanger losses as 12 inches water, and with a 3 percent gear loss, the net site rating is 6575 hp.

To improve the overall efficiency of the installation, we shall consider that the exhaust heat of exit gases is recovered by the generation of 150 psig process steam.

The cost of the combustion gas turbine with waste heat recovery exchanger is obtained from Figure 7.

Free-piston Gasifier. Since the free-piston gasifier is a relatively new prime mover, the writers thought it would be informative to include it in the cost comparison.

To meet the load requirement of 6200 hp, seven gasifiers, plus one spare unit, will be required. The gasifiers are manifolded together and the exhaust gases, at approximately 40 psig & 850 deg.FTT, are used to drive the expansion turbine. The installation includes fuel oil treating, free-piston gasifiers, piping, and the expansion turbine. The cost of the equipment is obtained from Figure 8.

Economics. The operating utility costs will be based on energy costs typical of the Gulf Coast area.

Electricity . . . 0.0065$/KW.hr

Natural Gas . . . 0.15$/MM.BTU

#6 Fuel Oil . . . 3.15$/BBL (approximately 6 MM BTU)

Cooling Water . . . 0.005$/gallon

Using Figure 1 for 0.15$/MM Btu natural gas and 85 percent boiler efficiency, the base cost of 600 psig, 750 degreesFTT steam will be 0.21$/-1000 pounds.

To arrive at unit yearly energy costs, Figure 2 is used. For example, the condensing steam turbine with steam at 0.21$/1000 pounds and a steam rate of 8 pounds/bhp.hr has a yearly unit cost of 13.50$/hp year. The annual total steam cost will then

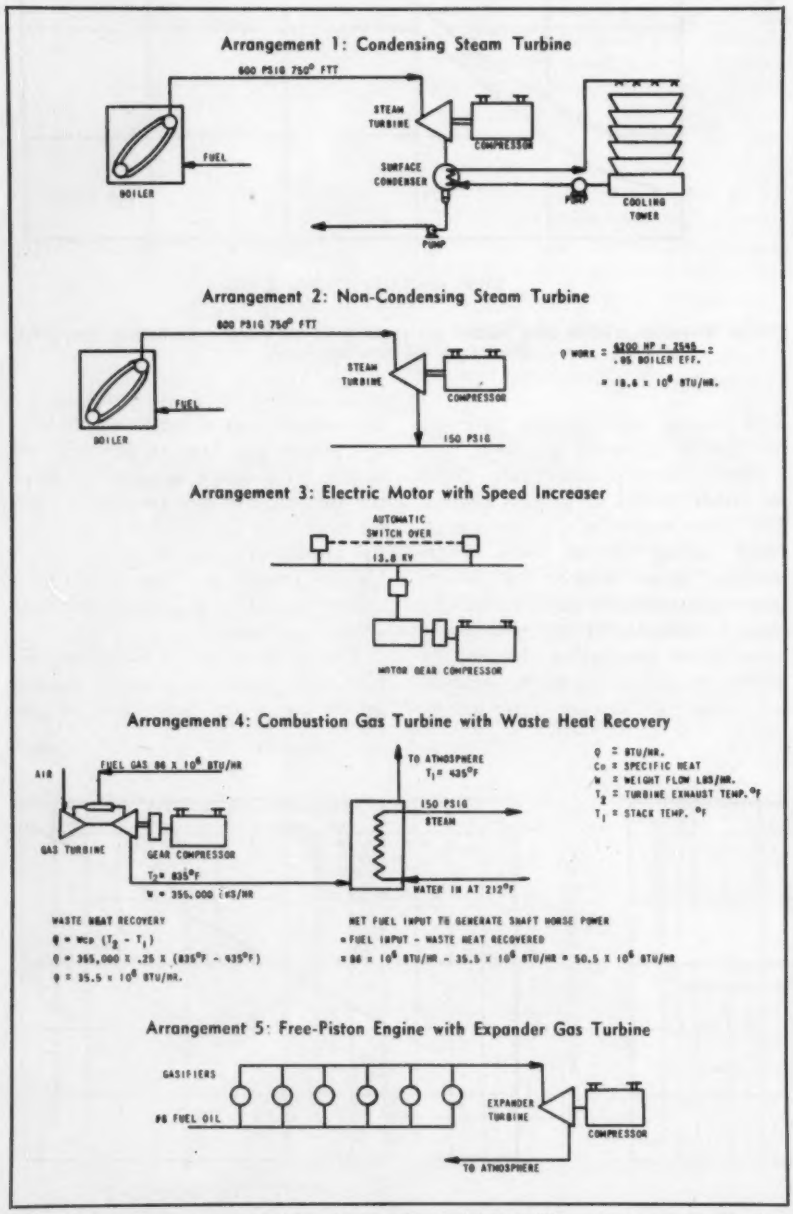

FIGURE 9—A compressor can be driven by any of several drivers. The various arrangements show how each driver is employed.

be 13.50$/hp year x 6200 hp = 83,500$/year.

Next, an allowance for operation and maintenance must be made for each particular application. This factor varies widely, and must be determined by the individual plant.

To evaluate the various arrangements, the estimated installed cost, plus three years' operating utility costs, are taken as an index. Three years have been arbitrarily selected as a basis for amortization, but any other payout period could have been used.

Tabulated in Table 2 are the costs of the various drive arrangements shown schematically in Figure 9.

Arrangements 1, 3, 4 and 5 are mainly concerned with the production of horsepower to drive a compressor load; and any steam produced is a useful byproduct. In Arrangement 2, the main consideration is the production of process steam. By generating the steam at a pressure higher than that required by the process heating load, and passing the high-pressure steam through a topping turbine, horsepower is obtained as a useful byproduct. Accordingly, in Arrangement 2, the boiler cost is charged with the incremental cost of going from a 150 psig boiler to a 600 psig boiler, and the fuel charge is at the rate of 2545 Btu/hp hour divided by the boiler efficiency.

Example Summary. The final driver selection depends upon local conditions, but certain general conclusions can be drawn from Table 2.

- Where both power and large amounts of process steam are required, back pressure or "topping" turbine drives will be economically advantageous.
- Electric motors usually provide the lowest investment cost.
- The over-all fuel efficiency of the combustion gas turbine is increased considerably by recovering the heat of the exhaust gases. In the absence of waste heat recovery, the fuel costs would be approximately 70 percent greater.
- Energy is usually the predominant operating cost, and deserves careful evaluation, since relative unit cost ($/hp year) will vary widely in different localities.
- This particular set of energy costs does not favor the free-piston gasifier with expansion turbine. However, in areas of high electric power rates or natural gas costs, the free-piston gasifier may eventually be competitive with other types of drivers,

TABLE 2
Estimated Costs

ARRANGEMENT	No. 1 600 psig Condensing Steam Turbine	No. 2 600 to 150 psig Non-Cond. Steam Turbine	No. 3 Electric Motor	No. 4 Gas Turb. w/Waste Heat Exchanger	No. 5 Free Piston Gasifier w/Expansion Turbine
Installed Horsepower	6,200	6,200	7,000	7,000	8,000
Site Rating (includes gear loss where applicable)	6,200	6,200	6,800	6,575	7,000
Load Horsepower	6,200	6,200	6,200	6,200	6,200
Installed Costs:					
Condensing Turbine w/Surface Condenser, etc	350,000	.....	.....	.....	.....
Non-Condensing Turbine	.....	300,000	.....	.....	.....
Electric Motors, gear & starting equipment	.....	.....	350,000	.....	.....
Combustion Gas Turbine	.....	.....	.....	800,000	.....
Gasifiers & Expansion Turbine	.....	.....	.....	.....	1,470,000*
Boiler—600 psig	270,000 (incremental)	1,050,000	.....	.....	.....
Cooling Tower & Pumps	100,000	.....	.....	.....	.....
Total	720,000	1,350,000	350,000	800,000	1,470,000
Credit for 150 psig Boiler	.....	920,000	.....	.....	.....
Net Total	720,000	430,000	350,000	800,000	1,470,000
Utilities—Consumption:					
Steam, lbs./hr	49,500	185,000	.....	.....	.....
Cooling Water GPM	5,000	.....	.....	.....	.....
Fuel Gas Btu/hr. x 10^6	.....	18.6	.....	50.5*	.....
Fuel Oil Btu/hr. x 10^6	.....	.....	.....	.....	47
Electricity KWHR's	.....	.....	4,900	.....	.....
Utility Cost per Year (8000 Hours):					
Steam 600 lb. .21 $/1000 lbs.	83,500	.....	.....	.....	.....
Cooling Water .005 $/1000 gals.	12,000	.....	.....	.....	.....
Fuel Gas .15 $/$10^6$ Btu	.....	22,300	.....	61,000	.....
Fuel Oil .52 $/$10^6$ Btu	.....	.....	.....	.....	195,000
Electricity .0065 $/KWHR	.....	.....	254,000	.....	.....
Operation & Maintenance	40,000	20,000	15,000	35,000	50,000
Total Cost per Year	135,500	42,300	269,000	96,000	245,000
Evaluation:					
Equipment Cost	720,000	430,000	350,000	800,000	1,470,000
3 Years Operating Cost	406,500	127,900	807,000	288,000	735,000
Total Evaluation Cost	1,136,500	557,900	1,157,000	1,088,000	2,205,000

* It is expected that this figure may eventually reach $800,000.
† Credit has been taken for waste heat recovery.

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How Turbines Can Work in Your Process

Take your choice, steam turbines or gas turbines; either can mean savings for the refinery operator.

W. B. Wilson, K. A. Drewry, M. M. Weiner and G. E. Holst
General Electric Company, Schenectady, New York

THE REFINERY or petrochemical plant utility and process engineers must have a thorough understanding of the characteristics of all types of turbines so they can capitalize on the economies that can often be realized by the use of these versatile prime movers for their applications.

Automatic extraction and noncondensing steam turbine-generator units, mechanical drive steam turbines and gas turbines, linked together or operated separately, should be considered for refineries or petrochemical installations, whether it be expansion and modernization of an existing refinery or the design of a new refinery.

In the past, the major factor preventing wider use of gas turbines in the petroleum and petrochemical industries was the limited number of sizes which the gas turbine manufacturers offered. The much wider variety of gas turbine sizes presently being offered by the gas turbine manufacturers, coupled with the fact that today's process plants are much larger and operate at higher pressures, insure future widespread usage of this versatile prime mover. In planning tomorrow's operations, it behooves the process engineer to analyze thoroughly the possible application of gas turbines in his process for a completely integrated, lower cost plant operation.

Gas Turbine Applications. Today's inflationary economic cycle poses many problems for the process engineer. His continuous battle against rising costs adds even greater impetus to his never ending search for a better way to do the job. One tool that has been receiving the process engineer's close scrutiny is the combustion gas turbine. The versatility of this self-contained prime mover permits its use to supply a wide variety of process requirements for lower cost plant operation.

Operating Principles. Before reviewing some of the potential applications of the gas turbine in the petroleum and petrochemical industries, perhaps a brief description of the gas turbine's operating principles will be helpful in understanding how this machine can be best utilized.

Figure 1 is a semisectional view of a 7000 hp simple-cycle, single-shaft gas turbine. Atmospheric air enters the machine through the air intake at the left and is compressed to approximately six atmospheres in the 15-stage, axial flow compressor. This high pressure air can then be diverted to a process, or as is the case

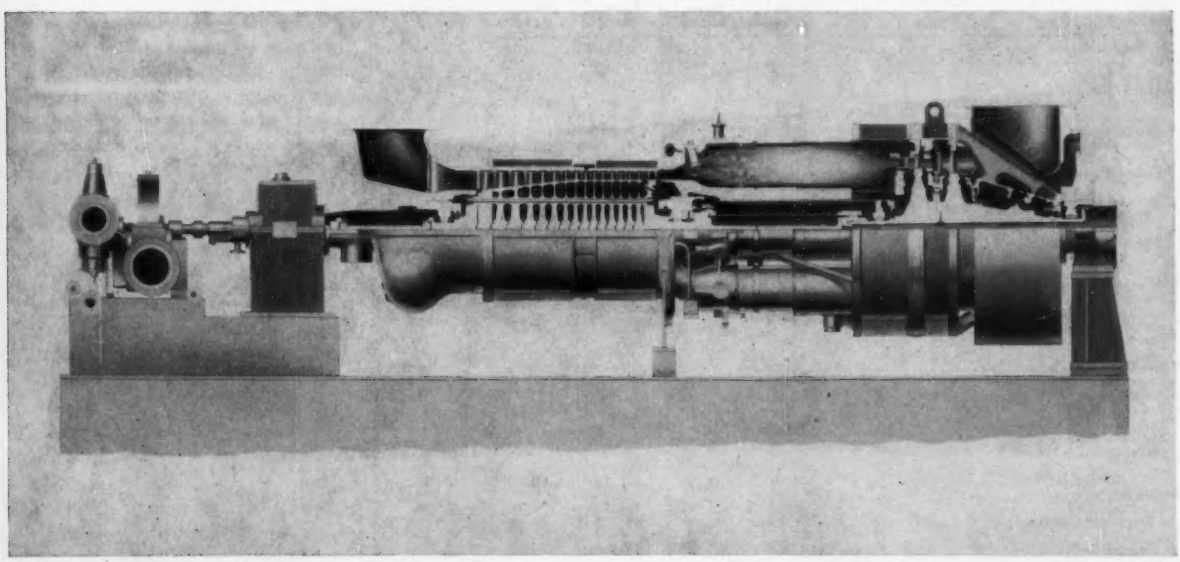

FIGURE 1—Atmospheric air enters at left, is compressed, heated in the combustion chamber and expanded through a two-stage turbine which supplies power to drive an axial-flow compressor.

with the standard gas turbine shown in Figure 1, the compressed air is passed into the combustion chamber where it is brought up to the required turbine inlet temperature by the combustion of fuel. Gas turbines are designed to operate on either natural gas, distillate oil, dual fuel, specification residual oil, or many process and refinery off-gas fuels. The resultant hot gases at temperatures of from 1400 to 1500 F. expand through the two-stage turbine which supplies the power to drive the axial flow compressor and the load.

In an instance where the full air flow from the compressor discharge is directed to a process, the combustion section of the gas turbine is eliminated and the exothermic reaction of the process supplies the heat to the air before it is expanded through the turbine. This will be shown later in a nitric acid process application.

The exhaust gas leaving the exhaust discharge casing at the right of Figure 1 is at temperatures of from 800 to 900 F. in this simple-cycle machine. The heat contained in these exhaust gases can be utilized for drying, as preheated combustion air, or to generate steam in an unfired exhaust heat boiler.

The speed range of the single-shaft machine is adequate for many applications in the petroleum and petrochemical industries; however, where a wider range of load shaft speed is required, a two-shaft gas turbine can be used. The two-shaft unit contains a high-pressure turbine which drives the compressor, and a low-pressure turbine that drives the mechanical load. The high- and low-pressure turbines are mounted on independent shafts that are assembled in one casing. There is no mechanical connection between the compressor turbine and load turbine shafts. This allows the low-pressure turbine which drives the external load to be operated at any speed required and is independent of the speed of the high pressure turbine which drives the gas turbine compressor. With this arrangement, the speed of the load turbine can range from approximately 35 percent to 100 percent to match the requirements of the driven equipment.

Figure 1 shows that the rotating parts, relatively few in number and assembled so that they are easily accessible, provide the simplicity of construction which is the basis for the gas turbine's inherent reliability.

Operating Experience. Although the gas turbine is the latest development in the design of prime movers, it is certainly far removed from the experimental stage. The gas turbine has long since proved itself as a prime mover and is at present in an advanced state of development that can be compared from the standpoint of reliability to its much older cousin, the steam turbine.

One of our first installations in the petroleum refining industry was in an Esso Standard Oil Company refinery in 1953. A 5700-hp simple-cycle, single-shaft gas turbine is used to drive centrifugal compressors in this light-ends plant process. The turbine exhaust is used in an unfired exhaust heat boiler to generate low pressure steam for the process. This machine has operated for 27,661 hours in the period from initial operation on November 17, 1953 to January 31, 1957 for a machine availability of approximately 98.5 percent. This figure includes all downtime, regardless of cause.

Perhaps the most conclusive evidence of the gas turbine's reliability and low annual operating cost lies in the fact that, like Standard Oil of Louisiana, nearly all of the large users of gas turbines, after a critical analysis of the operation of their initial units, have already placed orders for additional units or are planning for the addition of more gas turbines in the future.

Areas of Application. The gas turbine's versatility has challenged the imagination of application and process engineers since its inception. A list of the services that the gas turbine has to offer includes shaft power, compressed air, process steam, hot gases for direct drying of products, highly preheated air for process use, efficient use of process high energy waste gas and many more. Figure 3 illustrates these services. As shown here, high-pressure air for the process can be extracted directly from the gas turbine compressor and off process gas can be introduced into the turbine to make up the deficiency in flow. Advantages are accrued in extracting high-pressure air from the axial flow gas turbine compressor, as opposed to adding a driven centrifugal compressor, in the more simplified equipment arrangement, and in the fact that higher efficiency of compression is achieved in the axial flow compressor.

Figure 3 also shows the gas turbine's adaptability to extract useful work from many specification surplus process gases. In some processes, high-pressure, high-temperature surplus gas may be throttled to the atmosphere. In many of these cases, it

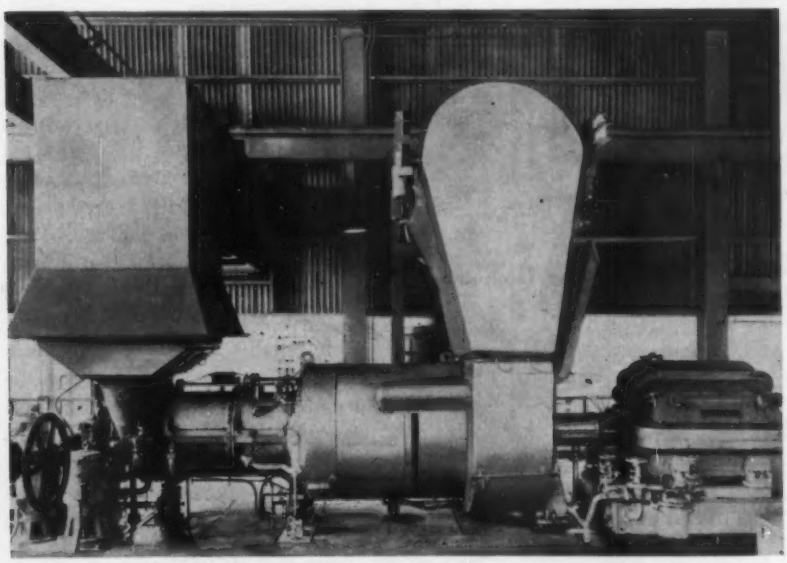

FIGURE 2—Esso's gas turbine drives a centrifugal compressor in an ethylene process. Note air washer ducts on left and exhaust ducts on right.

Turbines in Your Process . . .

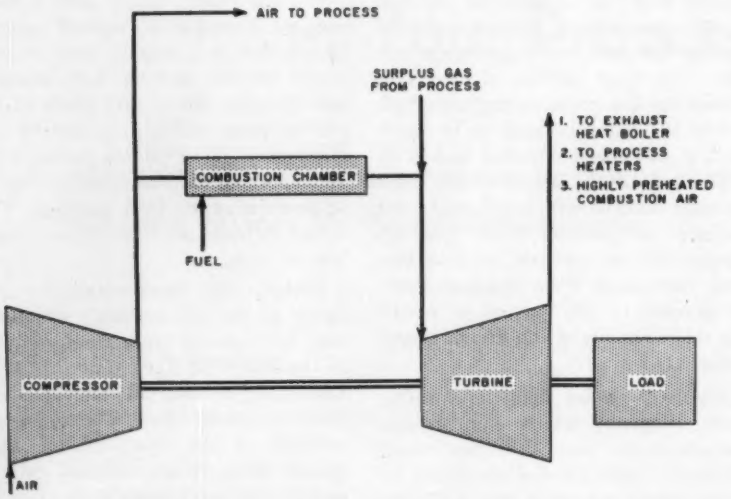

FIGURE 3—Gas turbine can extract useful work from surplus process gas.

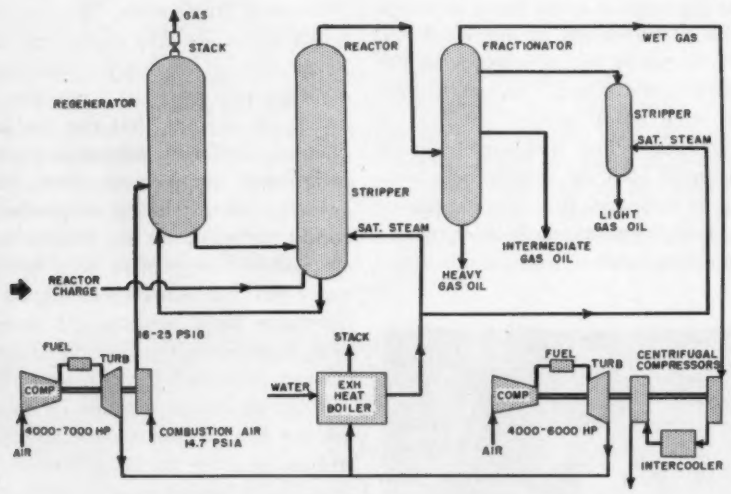

FIGURE 4—Two gas turbines fit into a fluid cat cracking process

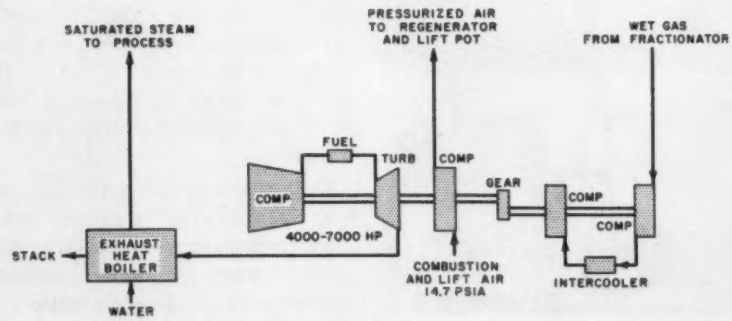

FIGURE 5—Thermofor cat cracking uses air at lower pressures which requires only one gas turbine.

may be possible to expand this gas through the gas turbine thereby converting a good deal of the energy to process use that would otherwise be lost.

The shaft load driven by the gas turbine may be a centrifugal compressor to supply process air at conditions or rates that cannot be adequately supplied by extraction from the gas turbine compressor, or may be one or a group of centrifugal compressors used to raise the energy level of the process working fluid. It may alternately be an electric generator or a pump.

Exhaust gas temperatures from a simple-cycle machine are in the range of from 800 to 900 F., and the heat contained therein can be utilized as highly preheated process combustion air, in process heaters, and in exhaust heat boilers to generate process steam. A typical 7000-hp gas turbine can generate over 40,000 pounds per hour of 150 psig saturated steam in an unfired exhaust heat boiler. Process requirements for greater steam flows can be satisfied by using a supplementary fuel fired boiler. Under these conditions, the gas turbine exhaust can be used as highly preheated combustion air, as it contains roughly 80 percent of the oxygen contained in standard air. When the exhaust of a 7000-hp gas turbine is utilized in this manner, it contains ample oxygen for a fuel fired boiler to generate over 300,000 pounds per hour of steam at a wide range of temperatures and pressures.

With the brief foregoing information as a basis of analysis, we are in a position to consider some of the specific applications of gas turbines to processes. Figure 4 is a simplified schematic diagram of a fluid catalytic cracking process which is representative of this process in general. In the application shown in this figure, two gas turbines are utilized. One is used to drive a centrifugal compressor which supplies low pressure combustion air to the regenerator for the purpose of burning the carbon off the spent catalyst. The second gas turbine is used in the gas recovery section to compress the wet gas product to the desired level. The gas turbines, as shown, exhaust to an exhaust heat boiler where saturated steam is generated for the process.

In the Thermofor catalytic cracking process, air is required at much lower pressures in the lift pot and regenerator than in the above fluid process; therefore, requiring less air compressor power. The gas turbine arrangement in this system would appear as shown in Figure 5. One gas turbine is used in this application to drive the combustion and lift air compressor, and the two intercooled wet gas compressors. The turbine exhaust passes through an exhaust heat boiler where steam is generated for the process. This process is capable of generating fairly large quantities of steam in the regenerator. In an instance where sufficient quantities of steam can be generated within the process to meet its needs, it may be possible to eliminate the exhaust heat boiler and combustion and lift air compressor, and utilize the turbine exhaust as combustion and lift air. As mentioned earlier, the gas turbine exhaust contains roughly 80 percent of the oxygen contained in standard air and is at temperatures in the range of 800 to 900 F. This arrangement will even further simplify the equipment used and reduce the initial cost of the plant.

The combustion gas turbine can also be gainfully employed in the fluid Hydroforming process. Figure 6 indicates one method of utilizing the gas turbine in this process. The regenerator combustion air is supplied by extracting part of the flow from the gas turbine axial compressor. This high-pressure extraction air is then cooled and compressed further in the shaft driven boost compressor before going to the regenerator. The gas turbine drives both the boost compressor and a centrifugal compressor which increases the pressure of the recycle gas to the level required for injection into the reactor. The addition of process gas back into the turbine (if available at a pressure of about six atmospheres) will increase the power output of the gas turbine. The gas turbine exhaust is used in a heat exchanger which preheats the recycle gas prior to injection in the reactor. Where the preheating of the recycle gas is required at temperatures above that of the gas turbine exhaust, it is possible to use auxiliary firing in or before the

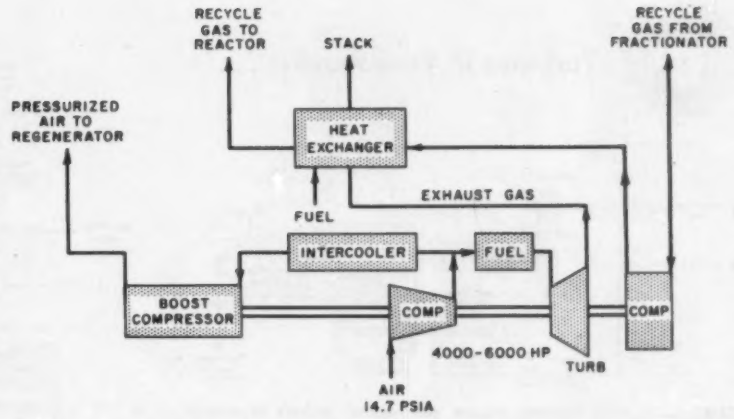

FIGURE 6—Air is cooled and boosted in pressure for use in Hydroforming regenerator.

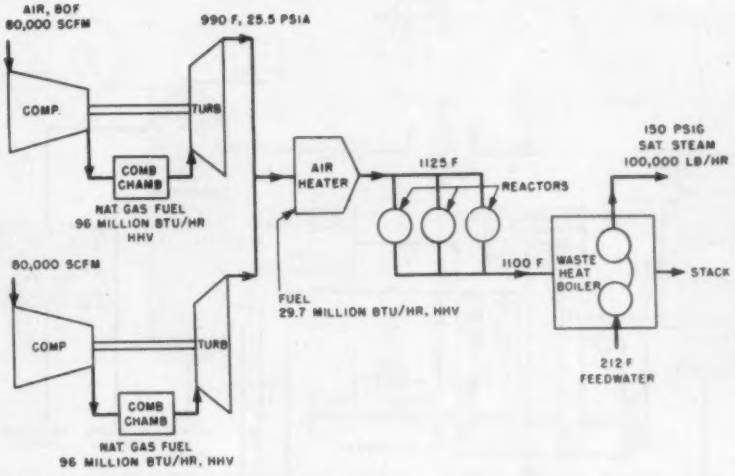

FIGURE 7—Gas turbine exhaust can be used for reactor catalyst regeneration in the dehydrogenation process for producing butadiene.

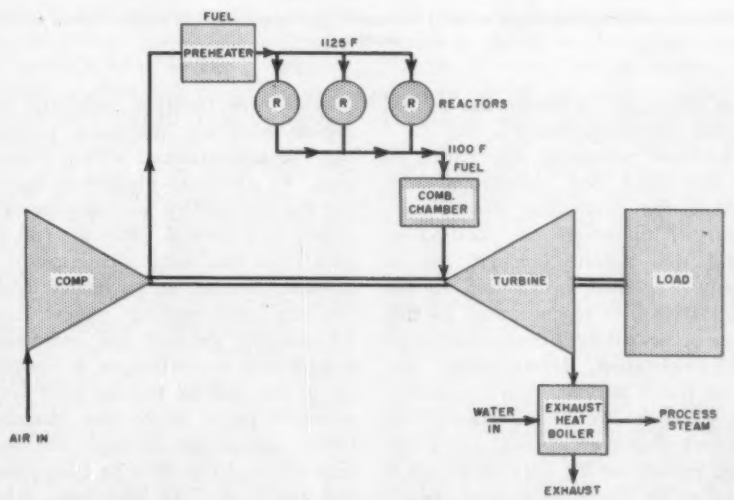

FIGURE 8—Alternate method of supplying reactor catalyst regeneration air.

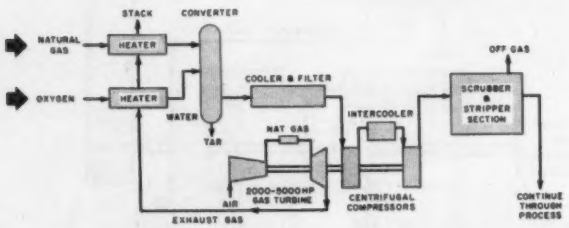

FIGURE 9—(Above) Turbine exhaust gas supplies preheat to natural gas and oxygen charge in acetylene process.

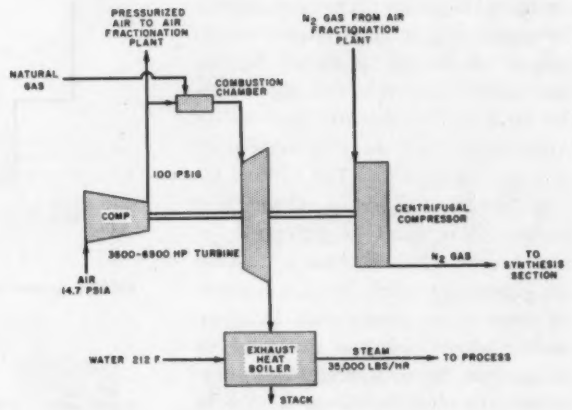

FIGURE 10—(Right) Gas turbine supplies some of the power for synthetic ammonia process.

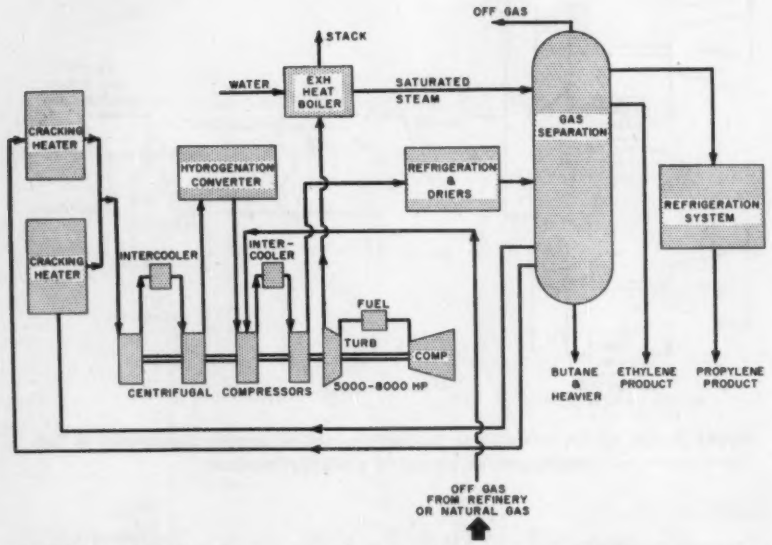

FIGURE 11—Gas turbine drives series of four centrifugal compressors in tandem for an ethylene process.

heat exchanger to obtain the desired recycle gas temperature level.

Another promising application is in the fixed bed dehydrogenation process for producing butadiene. Figure 7 illustrates one method of using the turbine exhaust gas as highly preheated, pressurized air for reactor catalyst regeneration. In this process, the catalytic reactors undergo dehydrogenation, regeneration, and steam purge periods. A system utilizing seven reactors would have three reactors on regeneration at any given time. Steam for the catalyst purge is supplied by the exhaust heat boiler. Although Figure 7 shows two back pressure gas turbines supplying the regeneration air, the same purpose may be accomplished with one large unit. An alternate method of applying the gas turbine to this process is shown in Figure 8. Here the full air flow from the turbine compressor is directed through an air heater to the reactors undergoing regeneration. The reactor exhaust gas, containing considerable excess oxygen, is brought up to the desired turbine inlet temperature in a combustion chamber before expanding through the turbine which drives both its compressor and the load. The load may either be a generator, or one of the gas compressors required in the process. The decision as to which of these methods to use would be based on the desired pressure level of regeneration. Regeneration in Figure 8 would occur at a considerably higher pressure level than that shown in Figure 7.

The production of acetylene is accomplished by many methods, one of which is shown in simplified schematic form in Figure 9. In this arrangement, the gas turbine drives two intercooled centrifugal compressors which raise the pressure of the cracked gas to the level required by the scrubber and stripper section. The exhaust gas from the turbine can be used to supply the heat required to preheat the natural gas and oxygen charge. A large acetylene plant of this type might produce on the order of 500 tons per day and have horsepower requirements of up to 10,000 hp, depending upon the design pressure of the system.

The manufacture of synthetic ammonia requires a large amount of shaft horsepower in the form of process compressor drive. A plant with a capacity of 300 tons per day would use roughly 15,000 to 20,000 hp in the form of compressor drive. Figure 10 indicates one arrangement of utilizing a gas turbine to efficiently supply some of these power requirements. A portion of the air from the turbine compressor may be extracted at 100 psi and passed to the air fractionation plant through a scrubber and external boost compressor. The

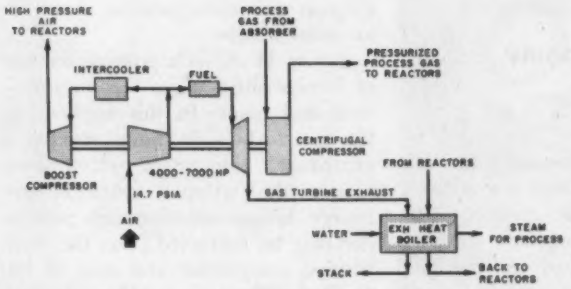

FIGURE 12—(Above) Centrifugal compressor in process gas path of an ethylene oxide plant employs gas turbine driver.

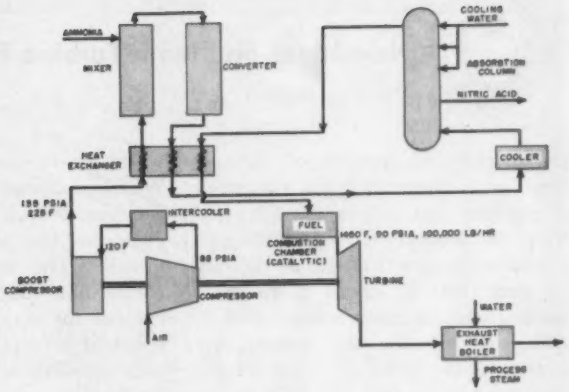

FIGURE 13—(Right) Energy in high pressure, high surplus gas can be expanded through a turbine to supply air for a nitric acid process.

major part of the air from the turbine main compressor is used as combustion and dilution air in the turbine combustion chambers. The turbine drives a centrifugal compressor which moves the nitrogen gas from the air fractionating plant to a point where it joins the hydrogen gas stream and is further compressed before entering the synthesis section. The gas turbine exhausts to an exhaust heat boiler where low-pressure steam is generated for the process.

The gas turbine can also be effectively applied in the ethylene process. Figure 11 illustrates a very simplified version of an ethylene plant in which the turbine drives four series flow centrifugal compressors in tandem and exhausts through an unfired boiler to supply steam for the gas separation section. Other compressor drive requirements in the refrigeration system can also be adequately supplied by a gas turbine.

Many petroleum and petrochemical processes, such as the ethylene process mentioned above, give off substantial volumes of low or intermediate energy combustible gas. Many of these gases constitute excellent gas turbine fuels. Where the off-gas is available at adequate pressures, on the order of 150 psig, it is feasible to start the gas turbine on natural gas or oil fuel and switch over to process off-gas fuel when it becomes available. When the volume of off-gas fuel is not sufficient to meet the full fuel requirements of the gas turbine, it can be used as a supplementary fuel and burned in combination with natural gas or with oil in a dual-fuel machine. A system operated in this manner can be made

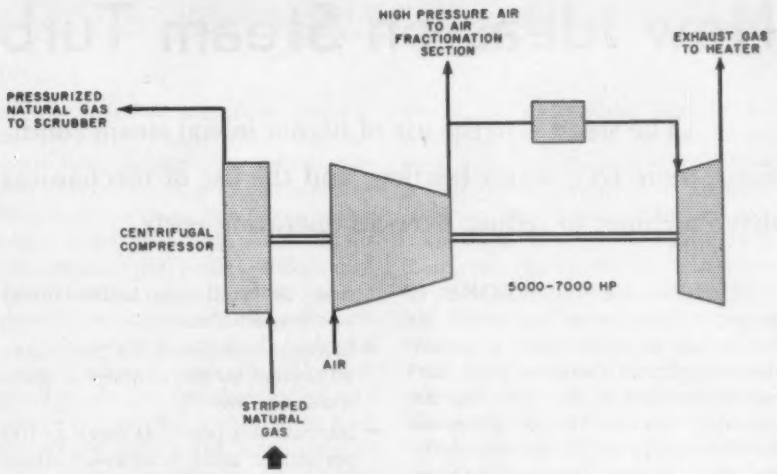

FIGURE 14—Gas turbine driven centrifugal compressor pressurizes stripped natural gas charge for methanol plant.

partially or completely self-sustaining. When the process off-gas is available at pressures lower than 150 psig, it will in general be necessary to install a suitable gas compressor capable of increasing the off-gas pressure to the required turbine combustion system level.

The ethylene oxide plant shown in Figure 12 employs a gas turbine driving a centrifugal compressor in the process gas path flow between the primary absorber and second-stage reactor. A portion of the gas from this centrifugal compressor is recycled to the primary reactor. The main gas turbine compressor supplies intercooled air to a boost compressor. (If a comparable quantity of off process gas is available at about 87 psi, the normal shaft rating of the gas turbine can be maintained by introducing this gas into the turbine.) This air combines with the ethylene charge going to the primary reactor and with the pressurized absorber discharge going to the second-stage reactor. The exothermic reaction in the reactors of this process makes it possible to generate steam by directing the process gas through an unfired boiler. Where additional process steam is required, the gas turbine exhaust can be used to supplement the heat requirements as indicated in Figure 12. Where additional steam is not needed, the turbine exhaust can be utilized in the process heaters.

Efficient use of the energy contained in high-pressure, high-temperature process surplus gas is shown in Figure 13. In this nitric acid process, the complete air flow of the main turbine compressor is directed to the process through an intercooler and turbine driven boost compressor. Ap-

proximately 80 percent of this air flow, in the form of a gas composed of nitrogen and oxygen, is discharged from the absorption column through a heat exchanger. This gas at roughly 90 psig, 900 F. enters a catalytic combustion chamber where fuel is added to increase the temperature of the gas to 1450 F. (This operation also reduces the NO and NO_2 in the waste gas to eliminate air polution.) When expanded through the turbine, the gas provides enough power to compress the air required for the process. The standard gas turbine combustion chambers are eliminated because the major portion of the heat required is supplied by the process and supplemented by the catalytic combustion chamber. The turbine exhaust generates process steam in an unfired boiler.

Figure 14 shows a possible method of incorporating a gas turbine into a methanol plant. In this application, the gas turbine is shown driving a centrifugal compressor which pressurizes the stripped natural gas charge before entering the process. Air may be extracted from the main turbine compressor and sent to the air fractionation section through scrubbers and external boost compressors. The turbine exhaust is used in the process heaters to preheat the charge.

New Ideas on Steam Turbine Economy

The trend is to the use of higher initial steam conditions, more feed water heating, and the use of mechanical drive turbines to reduce over-all operating costs.

TURBINE-GENERATORS to supply refinery steam and power are continuing to be installed to reduce over-all refinery operating costs. Savings in the cost of electric power are important because electric power use has increased about 80 percent in the petroleum industry and over 100 percent in the chemical and petrochemical industry during the past 10 years, as shown in Figure 15, and present studies indicate a continuation of this trend.

Turbine-generators listed in Table 1 indicate the range of sizes and steam conditions for units being installed in refineries.

Turbines, such as those in Table 1, generate electric power at a fuel cost less than 1 mil per kilowatt hour (based on 20 cents per million Btu) when supplying steam required for power and/or process use.

By careful over-all planning, it is possible for refineries to:

- Generate a part of their power with as little as one-half the fuel required in condensing steam turbine plants installed for power generation only.
- Double or triple this power generation with the same process steam flow by utilizing higher initial steam conditions.
- Increase this power 15 percent to 20 percent by the addition of feedwater heating.
- Increase this power as much as 100 percent or more with lower steam pressure in the process system.

The fuel chargeable to power in refineries using steam turbines to supply power and steam for process or other power uses depends on many things which include:

1. Initial steam conditions.
2. The pressure of lower pressure steam required for process or other power uses.
3. Efficiency of the prime movers.
4. The amount of steam extracted or exhausted for feedwater heating.
5. The amount of steam required for process.

TABLE 1

Kw Capability	Initial Steam	Extraction Pressure	Exhaust
6,250	850 psig—750 F	400 psig	200 psig
7,500	900 psig—900 F	565 psig	135 psig
11,000	850 psig—800 F	.....	235 psig
12,500	1250 psig—900 F	.....	400 psig
25,000*	1250 psig—950 F	600 psig	2½" Hg.

* Operated by Utility to supply refinery steam and power requirements.

Power and steam requirements are related and for any refinery operating condition can be expressed in "pounds of 'dry' process steam per hour per kilowatt or horsepower." This relation is one of the things that can be determined for an over-all refinery or any portion of the refinery and is one convenient variable that can be used in evaluating alternate systems. This concept is mentioned here because some of the data, here presented, will be plotted with lb/hr/kw as one variable.

With the trend to higher fuel and electric power costs, refineries are recognizing the economies that can be realized by the use of higher initial steam conditions. Maximum initial steam pressures and temperatures for industrial type (those to supply both steam and power) turbines in all different industries have followed the same upward trend as in the utility plants. Note that the initial steam conditions for the turbine-generators for refinery power plants, tabulated in Table 1, indicates that the refinery industry is taking advantage of economies available from the use of higher initial steam conditions.

The average rating of industrial turbine-generators has also increased —from 5000 kw to 17,000 kw in the last ten years. This increase in size has been a favorable factor in industrial power plant economy since the efficiency of a turbine increases with rating. This means additional low

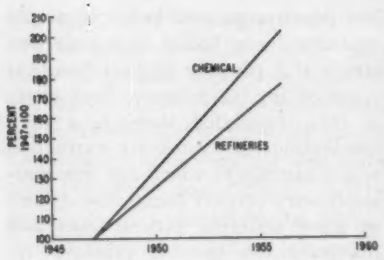

FIGURE 15—(Above) Power requirements in refineries have increased 80 percent in the past ten years.

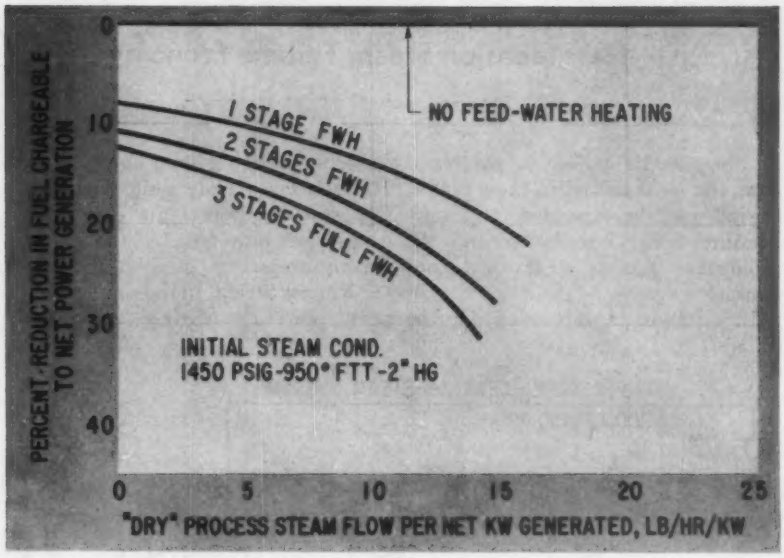
NO FEED-WATER HEATING
1 STAGE FWH
2 STAGES FWH
3 STAGES FULL FWH
INITIAL STEAM COND.
1450 PSIG-950° FTT-2" HG
PERCENT REDUCTION IN FUEL CHARGEABLE TO NET POWER GENERATION
"DRY" PROCESS STEAM FLOW PER NET KW GENERATED, LB/HR/KW

FIGURE 16—(Right) Feedwater heating reduces fuel chargeable to power as much as 30 percent in refinery power plants.

cost by-product power with no increase in steam extracted or exhausted for power or process use.

The use of higher initial steam conditions has an even greater effect on the amount of low fuel cost, by-product power that can be generated from each pound of steam required in process. For example, when process requirements are 200 psig, more than three times as much by-product power is available if 1450 psig steam is used instead of 400 psig. Selection of initial steam conditions can usually be based on economics without limitation and the power engineer has a free choice.

Large increase in by-product power generation is available when the process steam pressure is reduced. Though dependent on the process, care must be exercised to be sure the process engineer does not arbitrarily select a process supply pressure higher than actually needed for all or a part of the steam.

In most refineries, process steam is used at more than one pressure. Single automatic extraction noncondensing or double automatic extraction condensing turbines can automatically control steam pressure in the process system when supplying the varying quantities of steam required at each process level. The use of these turbines can minimize the flow of process steam to pressure reducing valves and increase the generation of low fuel cost by-product power.

The use of more feedwater heating is another way to reduce the fuel chargeable to power in refinery power plants. Figure 16 shows that feedwater heating can reduce the fuel chargeable to power as much as 30 percent or more in refinery power plants when steam requirements for process and the smaller mechanical drive turbines range up to 25 or more pounds per kilowatt hour generated.

The increased costs of fuel and power make it economic to install more feedwater heating in refinery power plants than might have been considered only a few years ago. In any refinery expansion, additional stages of feedwater heating should be evaluated to be sure the most economic balance is selected.

Extraction Turbines. In most refineries, there are one or more steam systems to distribute steam throughout the refinery from one or more central boiler house locations. Steam generated in waste heat boilers in the different process areas also feeds into this refinery distribution system. Boilers in the central boiler house would utilize the refinery by-product fuels such as refinery gas, refinery coke, CO, etc. With today's modern feedwater treating facilities, these boilers can be readily designed for steam conditions higher than those normally required for steam in the refinery distribution system. By installing boilers operating at higher steam conditions, it is possible to generate additional horsepower or kilowatts by expanding the steam from boiler pressure down to the pressure required for distribution through the refinery. The added initial investment for the higher pressure boilers is usually low compared to the gains which can be realized from the generation of this by-product power. With this arrangement, when the large turbines are located in the central location, there is no increase or change in the pressure or steam that must be distributed throughout the refinery. Such an arrangement is indicated in Figure 17.

Note that flexibility of operation is provided to cover a wide range of refinery operating conditions. For instance, the single large double automatic extraction admission condensing turbine can act as either an extraction or an admission turbine depending on the compressor loads and on the requirements for steam at the two lower pressure levels. Such an arrangement minimizes the number of small condensers that are often located with mechanical drive turbines in the process area. This arrangement also permits the economic utilization of high pressures and temperatures in the refinery without making it necessary to provide refinery distribution systems or purchase small mechanical drive turbines for the higher pressure which is practical for the central boiler house.

Refinery Steam Costs. Neglecting those few cases where it is economical for a refinery to purchase steam, a boiler plant must be provided to supply steam required for process, even if

all the electric power is purchased from the local utility. In these plants, capital must be expended for a low-pressure boiler installation and the piping for process steam and condensate.

In addition, a substation for the incoming power will be required. This is not usually a significant item of cost but represents capital that must be provided by the user in many areas.

Process Steam. In the simplest refinery power generating station, the low-pressure process boiler is simply replaced by a boiler that generates steam at a pressure higher than that required for the refinery. This steam is then expanded through a non-condensing or automatic-extraction steam turbine(s) which can automatically vary process steam flow in one or more different process lines and maintain the process pressure required. The same operating labor is required in either of the boiler plants so this labor can still be rightfully charged to process instead of power generation.

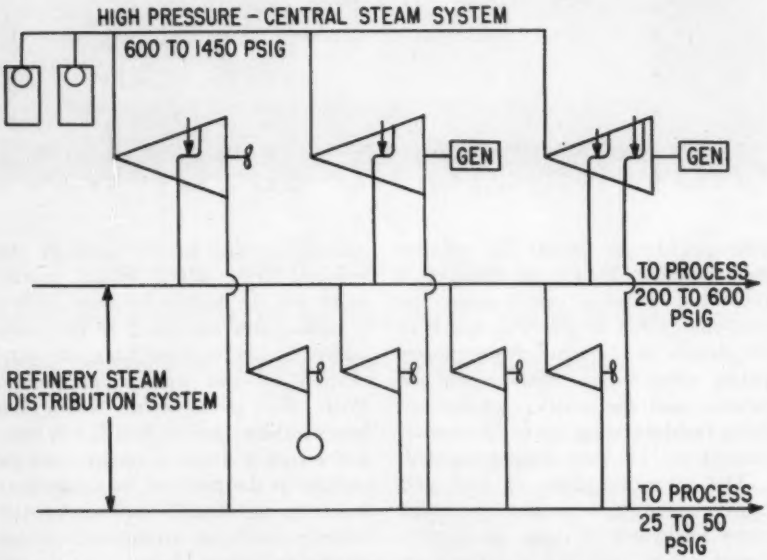

FIGURE 17—Operating boilers at higher steam conditions provide added horsepower by expanding steam to refinery distribution system.

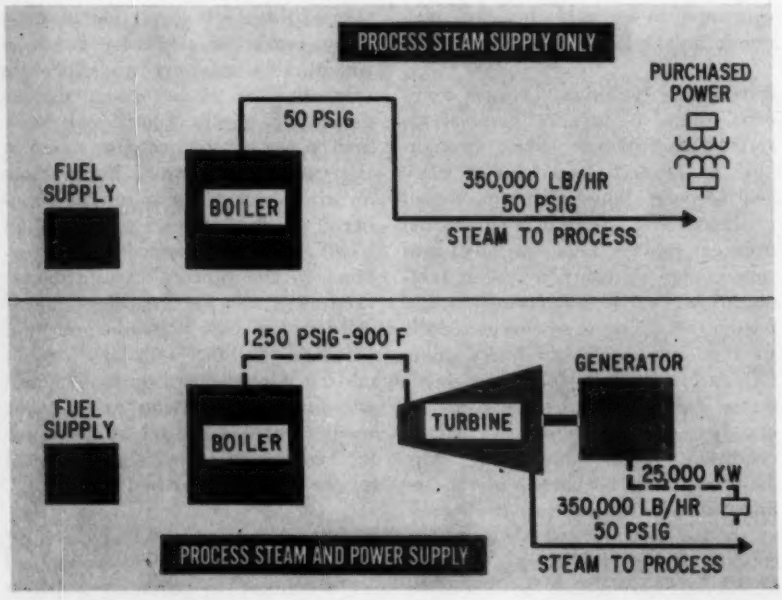

FIGURE 18—Compare the difference in plants using low-pressure boilers for process steam and plants with power boilers and by-product power generation.

Diagrams in Figure 18 indicate the differences in the simple power plant for steam supply only and the plant with turbine-generator to supply both kilowatts and steam for process.

Steam flow, in lb/hr, is the same for both plants and the refinery steam piping is the same. The only investment costs chargeable to power generation should be the difference between installed cost for a low-pressure process boiler with its pumps and feedwater treating facilities plus a substation for purchased power, and a high-pressure boiler with its pumps and feedwater treating facilities plus the cost of installing the turbine-generator. A smaller substation may be necessary for purchased power.

If it is desired to maintain kilowatt output when refinery steam requirements fluctuate or when they may be temporarily curtailed, then a condensing automatic-extraction turbine-generator should be installed. As mentioned earlier, this large condensing unit can be designed for admission operation if desired to minimize the number of small condensers necessary in the process areas.

Utility-Refinery Arrangements. Although most by-product power generation has been in power plants owned by industry, there have been some notable exceptions of industry and utility cooperation where both power and steam have been supplied by the utility. This arrangement has attractive possibilities and may be used more in the future.

Geographical location of the refinery and practical utility power plant sites is perhaps one of the most real obstacles in this kind of arrangement. One of the most recent applications of this kind is a utility operated power plant which includes two 25,000 kw automatic extraction condensing tur-

bine-generators to supply steam and electric power for a large east coast refinery. Another utility has installed two 225,000 kw extraction turbine-generators with the extraction steam being piped approximately one mile to a large east coast refinery. Utility power plant installations to supply both steam and electric power for refinery operations have worked out very satisfactorily in several instances and this possibility must not be overlooked.

Now is the time to consider your future refinery requirements. An analysis of the points brought out in this article tailored to your conditions may very well prove to save you hundreds of thousands of dollars by the proper selection of automatic extraction steam turbine generators.

Mechanical Drive Turbines. Mechanical drive steam turbines are particularly well suited for refinery applications, and in recent years, there has been a rapid increase in their use to reduce the cost of steam and power for refineries of all types. In this section, we will demonstrate the fuel cost chargeable to power, list other advantages of turbine drive, show some existing applications and suggest refinery applications for mechanical drive steam turbines that should be evaluated.

In many refineries, waste or by-product fuels can generate steam at the pressure required by steam turbines powering large adjustable speed compressors and other essential process drives. Even with fuel costing 20 percent per million Btu, steam turbines can supply power at a fuel cost less than 1/10 of a cent per horsepower-hour when exhausting or extracting steam for process or other power uses. The use of higher initial steam conditions will increase the amount of this low cost power available and minimize the amount of higher cost condensing turbine power that is required for over-all refinery operation.

The curves of Figure 20 show the effect of initial steam conditions and the process steam pressure on the amount of low cost by-product power that can be generated by steam expanded through the turbine and exhausted or extracted for process use.

In addition to the very low fuel cost chargeable to power, other characteristics of the steam turbine that can be utilized to advantage in the refinery include:

- Adjustable speed drive to provide operating flexibility when refinery requirements vary.
- Governing specifically designed to automatically respond to any process pressure or other control variable desired.
- Operating speeds to match the speed requirements of today's modern high speed compressors—eliminating the need for a step-up gear.
- Horsepower ratings to match the exact requirements of driven apparatus.
- Unaffected by ambient air temperatures, or conditions.
- Simple to install and operate.
- Requires minimum attention from the operator.
- Suitable for installation in refinery areas where there is an explosion hazard.
- Can exhaust or extract the varying quantities of steam at the pressure required for process.
- Proven reliability as evidenced by installation of over 188 turbines totalling 435,703 hp, over the past seven years.

One important application for turbines is to drive large high speed compressors, but they might well be considered the work horse of the refining industry because they are used

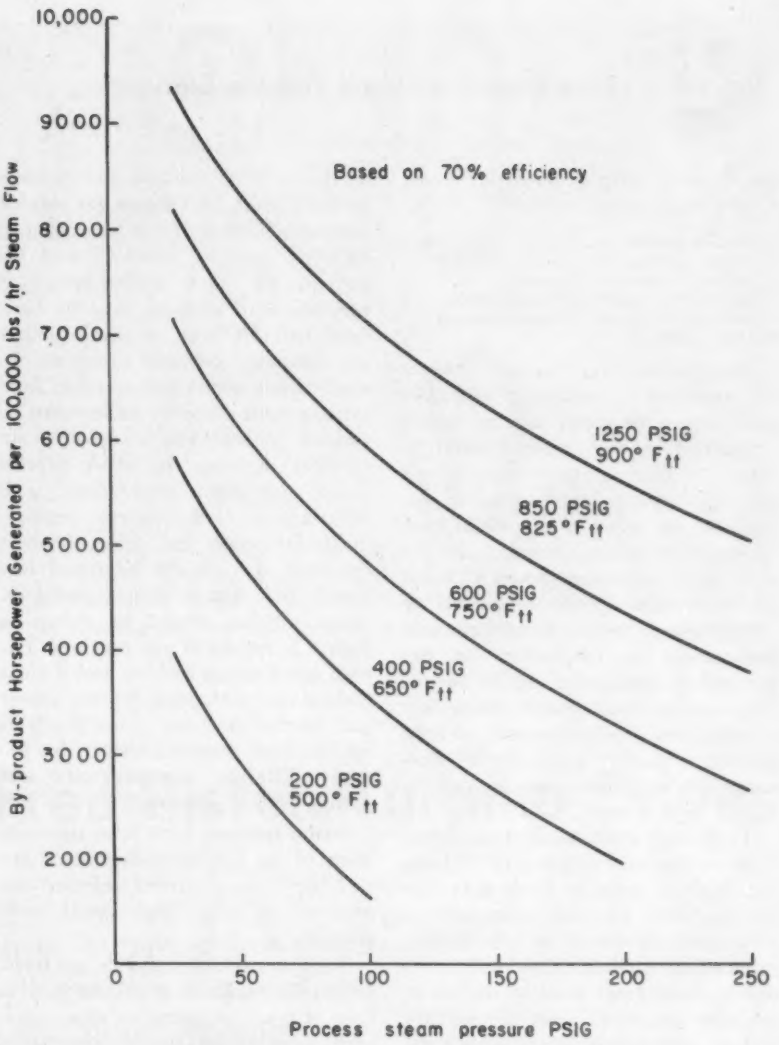

FIGURE 19—Compare the by-product power that can be realized by holding the process steam pressure constant and varying the initial steam conditions.

for so many different essential drives. Other applications include:

1. Hot oil pumps
2. Charge pumps
3. Lift air blowers.
4. Boiler feed pumps
5. Boiler feed drives
6. Fire pumps
7. Drives for small emergency generators
8. Miscellaneous process pumps

Mechanical drive steam turbines are available in ratings up to 25,000 horsepower, or more, and at speeds required in the refining industry. These turbines include noncondensing, condensing and automatic extraction as required to meet each specific application. Some of the recent applications are shown in Table 2. Note that speeds range up to 10,500 rpm. Steam conditions and horsepower are dependent on the particular application requirements. Turbines are available for the widely varying drive requirements of the refining industry—utilize their characteristics to reduce costs in your refinery.

The larger mechanical drive steam turbines can take steam directly from the highest pressure boilers in the refinery while the most economic arrangement for many of the smaller mechanical drive turbines will be to utilize steam from some of the lower pressure boilers or from the extraction or exhaust of the larger mechanical drive or generator drive turbines. The arrangement in Figure 17 shows larger turbines installed to take advantage of the economies of high initial steam conditions to generate power, mechanical or electrical, from the steam expanded to the lower pressure level which is economic for the smaller turbine drives.

Steam for mechanical drive turbines might also be supplied from fuel-fired exhaust heat recovery boilers installed to recover heat from and utilize the oxygen in combustion gas turbine exhaust.

Figure 5 in the gas turbine section of this article indicates gas turbines as the drivers for various gas and air compressors in different process units such as catalytic crackers and reformers. In many applications, gas turbines with exhaust heat or fuel-fired exhaust heat recovery boilers are the most economic drives particularly when steam generated in fired exhaust heat recovery boilers can be utilized in mechanical drive steam turbines required for other process drives. For other applications, with different over-all refinery requirements for power and steam, the most economic drivers will be steam turbines, and under these conditions, steam turbines would be shown in Figure 5 instead of gas turbines. The high speed steam turbine and the gas turbine are both tools for the power and process engineers to use in selecting the most economic drivers for the many different compressors and pumps in their refinery.

Steam turbines have been the work horse of the refining industry and are still the type of driver selected for most of the large high speed compressors.

Turbine materials and design techniques that have been proven in millions of hours of operating experience with large steam turbine-generators have been utilized in the design and manufacture of simple, reliable mechanical drive steam turbines to utilize the higher temperatures and pressures now economic in the refining industry.

With the flexibility of operation, the simplicity of control, the ability to minimize refinery heat balance control, the inherent reliability of steam as a source of power, and the proven reliability of modern mechanical drive steam turbines, they must not be overlooked in expanding existing refineries or planning new refineries. # #

TABLE 2

Rated HP	Speed	Initial Steam Conditions	Extraction Pressure	Exhaust
7170	8000	500 psig—750 FTT		0 psig
3450	9600	600 psig—750 FTT	255 psig	55 psig
760	10000	450 psig—690 FTT		150 psig
2250	10500	600 psig—750 FTT		150 psig
5700	5400	600 psig—750 FTT	45 psig	3" HgA
8050	6800	450 psig—690 FTT		4" HgA
10000	6500	580 psig—730 FTT	180 psig	6" HgA

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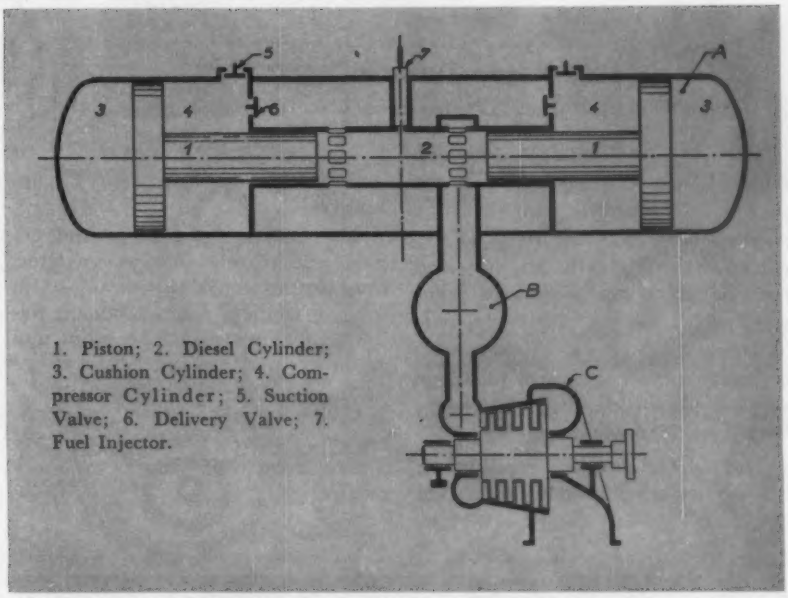


FIGURE 1—A free-piston gas generator is like a two-stroke diesel engine with opposed pistons.

Europe Likes Free-Piston Turbine Drives

Here's a roundup of European free-piston gasifiers for turbine drives. It tells you how they work and advantages for application to your plant's operations.

Leo Walter
Cloucester, England

FREE-PISTON ENGINES are a new rising star in European operations. The chemical companies are expressing a striking interest because of certain advantages which the free-piston engine possesses over conventional prime movers. This survey will present some of the design considerations for the use of this novel engine in refineries and petrochemical plants where conditions for its use seem favorable.

Main Features. A brief technical description of engine sets comprising a gas turbine supplied by one or more free-piston gas generators is as follows: Figure 1 shows diagrammatically a free-piston gas-generator and turbine set. The gas-generator may be considered as a two-stroke supercharged diesel engine with opposed pistons, expansion being extended down to atmospheric pressure in a turbine. The work of expansion of the gases in the engine cylinder is used to compress the supercharge air, the forces acting on the engine pistons being directly transmitted to the compressor pistons. A second stage of expansion takes place in the turbine with a more efficient use of the constructional material than in the normal diesel engine, impulses being constant and relatively low due to the high speed of the blading which transmits them. Useful energy is transmitted to the turbine shaft (Figure 2).

The elimination of connecting rods and crankshafts means considerable simplification of construction and in addition permits the stroke and dead center positions of the pistons to be suited to the operating conditions of the set. Thus, the pressure in the engine cylinder may be kept within permissible limits in spite of the delivery pressure to the turbine varying from 0 to about 4 kg/sq. cm. On the other hand, the elimination of the crankshaft and bearings will permit the use of pressures higher than those permissible in diesel engines. The designers claim that the principle of operation of free piston sets carries a number of advantages.

Light Weight. The expansion of the gas achieved in the blading of a turbine revolving at high speed will result in a large saving in materials over a conventional diesel engine.

There is at present one single type of gas-generator suitable for every application and particularly for those

requiring sturdy machines. With the present methods of construction, free piston sets weigh from 10 to 12 kg. per hp, according to the power, which corresponds to the weight of high-speed diesel engines. While the type of construction of the gas-generators is similar to that of slow or moderate speed diesel engines, the latter weighs from 5 to 10 times more.

The light weight of free piston sets is a particularly important advantage in the marine field. Light weight is also desirable in land sets, since a saving in shipping cost will be obtained. As an example, an 8000-hp plant comprising eight gas-generators of eight tons each and one gas turbine may be transported on 10-ton trucks.

It is also claimed that the following advantages make the plants very suitable for refinery operation: small over-all dimensions, flexibility of installation and operation, and ease of maintenance. Elaborating the last point (of special interest to the refinery engineer), a French firm claims the following:

The injection equipment and engine pistons rings of gas-generators must be inspected periodically as in the case of diesel engines, but the following features should be taken into account:

- The over-all height of a gas-generator does not exceed the height of a man, every component is easily accessible.
- The heaviest part to be dismantled, the compressor cylinder, weighs 600 kg. (1320 pounds).
- The heaviest part of the moving parts, the compressor piston, weighs 250 kg. (550 pounds).
- The engine pistons may be removed in 20 minutes.
- The following operation: stopping a gas-generator which is on load, withdrawing the moving parts, inspection of the pistons, re-assembly and re-starting; may be performed in less than one hour.
- All spare parts are completely interchangeable and may be assembled in position without adjustment of fitting work.
- All spare parts may be transported by light plane or delivery van.
- Maintenance of the gas-generator may be undertaken by the staff without specialist knowledge, after a few weeks of instruction.

The use of a single type of gas-generator for power of from 1000 to 10,000 hp, has allowed the use of extensive production tooling. This will result in:

- A high standard of machining.
- Complete interchangeability of components.
- Short delivery periods.

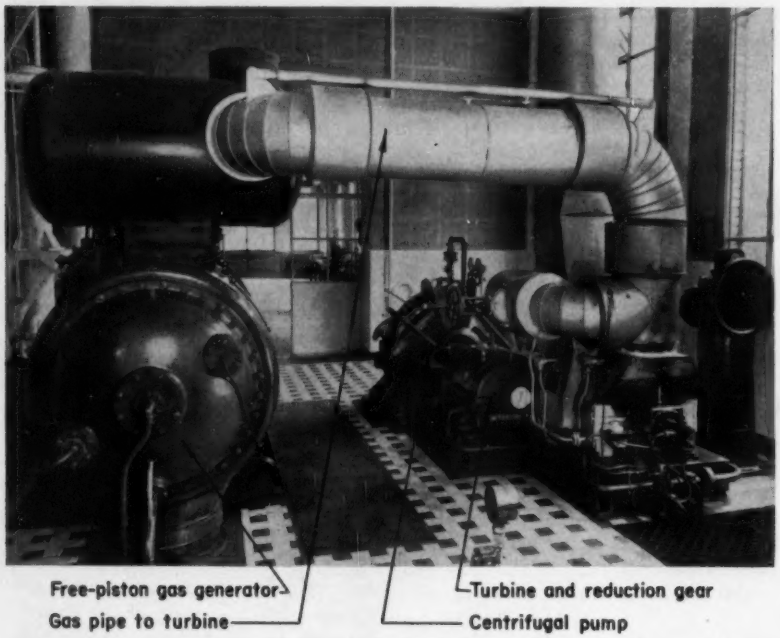


FIGURE 2—Only a gas pipe connects a pump and turbine to the free-piston gasifier.

Controls. The control system for gas-generator power plant are of two types: (1) Individual controls may be used on each gas-generator for starting, stopping, and for operation over the load range; or, (2) over-all control systems influencing all gasifiers and the gas turbine simultaneously. In an electrical generating set, a servo-valve connected to the circuit-breaker is used to reduce the rise in speed when the electrical load is suddenly reduced. A characteristic of free-piston, gas generator, power sets is that an increase in power requires a period of time to become effective.

High Efficiency Operation. The absence of bearings to transmit the power of the engine pistons permits the use of higher compression pressures than in the case of diesel engines. The fuel is burned at high pressure and temperature in the engine cylinder and the thermal efficiency of the cycle is very high.

The surface of the engine cylinder is small in relation to the quantity of fuel burned, and heat losses through the walls are reduced. This will result in an increase in efficiency and in a reduction in the flow of cooling fluid.

Finally, friction losses are also less than in a conventional Diesel engine, and the adiabatic efficiency of a

free piston gas-generator, varying with the compression ratio, is about 44 percent and may very likely be improved appreciably.

The over-all efficiency of a free-piston gas-generator and turbine set depends on the efficiency of the turbine and increases with turbine power. Specific consumptions of 170 gr./ch./hr. (.38 lb/hp/hr) measured at the turbine shaft have been recorded for 2000 hp sets.

The size of the engine cylinder, the temperature and pressure levels during combustion, the large quantity of excess air and the quality of the scavenging explains the ability of the free piston gas-generator to use the heaviest fuels.

The change-over from gas to heavy fuel oil is carried out very easily, without having to alter the control settings of the gas-generators.

The low specific consumption, the use of heavy fuels, the ease of maintenance and the high utilization factor make the industrial operation of free-piston sets very economical.

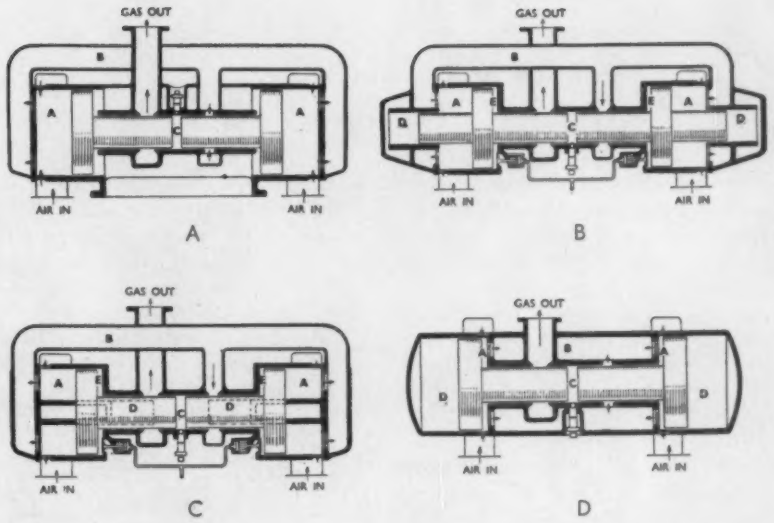


FIGURE 3—Today's gasifier designs are opposed-piston machines with inward or outward compression.

Advantages of Compounding. The free piston/gas turbine combination belongs to the generic class of compound, internal combustion prime movers. In any compound scheme, a displacement type of pressure transformer (in practice a cylinder and piston element) is associated with a rotating aero-dynamic flow machine (in practice a gas turbine). The principle of compounding has well known thermodynamic advantages leading to a low fuel consumption. The advantages arise in that each element of the compound scheme handles the appropriate part of the thermodynamic cycle. That is, the piston element handles the high pressures and the turbine element handles the large volumes. An efficient cycle demands that pressures should be higher than a turbine can readily handle and that volumes should be larger than the piston can easily accommodate.

The fuel economy which can be shown in several applications of the free piston gas generator, is mainly the result of compounding. However, when an attempt is made to pool the good qualities of two dissimilar partners, the danger is always present of mixing the wrong qualities instead. The free piston principle is one of the very few practical methods which have made it possible to use the theoretical advantages of the compounding principle. For this desirable condition the properties of the free piston enumerated earlier are largely responsible.

Advantages and Limitations. Some special advantages and limitations of the free piston/gas turbine combination are worth mentioning at this point. The compounding scheme so created is properly called a balanced scheme, in which the piston element and the turbine element are connected only through the gas supply. This arrangement is a limitation in so far as the supercharging pressure of the power cylinder must be the same as the delivery pressure of the compressor cylinder, but on the credit side the dynamic complications of a mechanical interconnexion are avoided. In this manner, it is possible without special difficulties and is advisable to join a number of free piston units to a single turbine. It is only necessary to ensure the correct timing of each pair among the several units.

An ingenious device to ensure such "phasing" between the units of a pair has been proved reliable and any number of pairs can be joined without further precautions. All the installations in operation at the time of writing have proved that the control and phasing problems of all free piston/gas turbine combinations have been solved, whether one or more gas generators are employed, and that any remaining gas pulsations have no detrimental effect on the blading of the gas turbine. A telling advantage of the compounding principle, which is found in the free piston/gas turbine combination, is the relatively low gas temperature at turbine inlet. Thus, all existing installations of this type operate with a turbine inlet temperature of appreciably less than 500 C., which is sufficient for good efficiency and adequate output of the unit. Often it has been possible to use ferritic steel for the turbine blading.

While, theoretically, compound schemes with a better fuel economy than the diesel engine can be envisaged, the margin is in practice reversed by the additional losses associated with the transfer of the working medium from one element to another, a transfer inseparable from compounding. When using a free piston gas generator the efficiency of the diesel engine is at least nearly maintained. However, as a consequence of compounding, the peak efficiency is also nearly maintained at part load, usually down to one-half of full load, and the loss of efficiency down to one-quarter remains tolerable.

Gasifier Designs. Figure 3 illustrates various gasifier designs. All types to date are opposed-piston

machines with either inward or outward compression. The simplest arrangement of the latter type is shown in Figure 3A. As the pistons move out under combustion pressure, they compress air in the compressor spaces (A) and discharge it through nonreturn valves into scavenge trunk (B), whence it scavenges the two-stroke diesel-type cylinder. Subsequent expansion of the residual compressed air in the compressor spaces must provide sufficient energy to return the pistons to their inner position and thus compress the air trapped in the diesel combustion chamber (C).

An undesirable result of using compressor spaces for bounce energy is that the volumetric efficiency of the compressor is lowered, which tends to increase machine size for a given output. There are also inherent starting difficulties in the particular layout illustrated. More important than either of these points—and indeed decisive in rendering the scheme impracticable—is the problem of controlling the peak pressures in the diesel cylinder over a range of loads. At the design load, the length of piston stroke and the bounce pressure in the compressor spaces would be arranged to give a suitable pressure in the combustion chamber (C). If the load were reduced by injecting less fuel, the outward stroke of the pistons would shorten and more expansion energy would be available in the compressor spaces; this would drive the pistons together with excessive force and generate too high a pressure in the diesel cylinder.

These drawbacks can be overcome by adopting an additional pair of pistons and cylinders, known as direct bounce cylinders, to supply the piston return energy. A familiar layout of this type is shown in Figure 3B with the direct bounce cylinders denoted by (D). In recent designs, the overall length has been reduced by placing the direct bounce cylinders (D) inside the compression and power cylinders, as sketched in Figure 3C The reverse bounce spaces (E) are used for starting.

Gasifiers of this type are started under atmospheric supercharge conditions, the air pressure in the direct bounce spaces being adjusted to provide sufficient energy for compression ignition in the diesel combustion chamber. As more fuel is injected, the scavenge pressure begins to build up. If the inner dead point of the pistons remained unchanged, the pressure in the combustion chamber would rise in proportion to the scavenge pressure until, at six atmospheres, it would reach a figure of about 300 pounds per square inch, before combustion. Pressures of this order are not permissible from the viewpoint of either liner or piston ring strength, so the combustion chamber volume must be increased by altering the pressure in the direct bounce spaces.

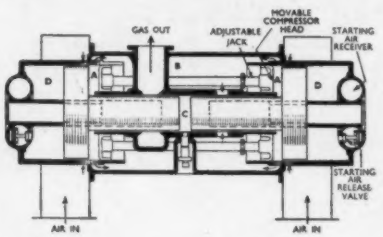


FIGURE 4—One gasifier design employs movable compressor heads which improve its starting characteristics.

Another operating characteristic of the type is the automatic relationship of load and piston stroke. Assuming the gasifier discharges to a fixed orifice turbine, any reduction in fuel supply is at once reflected in a shorter piston stroke and a consequent fall in volumetric efficiency. The machine automatically attains a condition of equilibrium, where the energy absorbed by the compression process, with the addition of friction losses, equals the energy output of the power cylinder. Safe combustion pressures must, of course, be ensured by control of the bounce pressure.

Figure 3D illustrates the simplest type of inward-compressing gasifier. Here the outer sides of the pistons serve as direct bounce spaces and the inner sides as compressor spaces. Starting is effected by moving the pistons to their outermost position and then injecting a fixed quantity of compressed air into the bounce spaces. Control of combustion pressure under varying load conditions is readily achieved by an automatic device which transfers air from the bounce spaces to the scavenge case or vice versa, and thus alters the piston stroke. This transfer of air is possible because the scavenge case pressure remains substantially constant at a given load condition, whereas the pressure in the bounce spaces is rhythmically rising above and falling below the mean scavenge pressure.

A disadvantage of the inward-compressing layout is that the volumetric efficiency of the compressor falls off as load is increased. This is because the clearance between the compressor piston and the head of the compressor cylinder becomes steadily greater as automatic adjustments are made to the inner dead point of each piston. Up to a pressure ratio of 3-4 atmospheres this effect can be compromised to some extent, but, at higher pressures, some additional complication becomes necessary. One attractive possibility is to employ movable heads for the compressor cylinders (Figure 4), which would give a suitably generous compressor clearance at starting and a smaller one at full load.

Test Performance. Another test indicates the thermal efficiency of a gas-generator, as shown in Figure 5, together with the corresponding specific fuel consumption, plotted against the gas delivery pressure. The variation in the turbine power output is also plotted on the same base. The more usual method of plotting the specific fuel consumption is against the power output as in Figure 6. This shows the results on a gas hp basis obtained on a gas-generator, rated 420 gas hp, at full load, and a gas pressure of 50 psi (gage). The specific consumption at part-load is slightly better than that shown on Figure 5, because a scavenge-air bypass valve is used to avoid an unnecessary amount of scavenge-air being passed through the diesel cylinder, to reduce the pumping losses.

The specific fuel consumption on a shaft horsepower basis depends on the turbine efficiency, on the gas transmission losses and the losses in the reduction gear. All these depend to some extent on circumstances such as the size of the set and the speed of the output shaft, i.e., the number of stages of gear reduction.

Typical efficiencies at full load may be given for a well-designed 2000 hp set with a single-stage reduction gear, as follows:

Thermal efficiency of gas-generator into gas, 43 percent; Turbine efficiency, 88 percent; Gas transmission (loss 2 percent) efficiency, 98 percent; Reduction gear (loss 3 percent) efficiency, 97 percent. This results in an efficiency on a shaft horsepower basis of 36 percent. The specific fuel consumption for a calorific value of 10,150 chu per pound (18,300 btu/pound) would then be 0.386 pound per shp/hour. This figure is about the best that can be obtained at present for a continuous duty rating, and it does not include an allowance for power absorbed by auxiliaries.

Figure 7 shows the variation of turbine-torque with speed, and the corresponding power and efficiency, as percentages of the values at the optimum speed.

Turbines are normally designed with a maximum speed no greater than the optimum, but where a large ratio of starting torque to full speed torque is required, the design can be modified (chiefly by providing a larger number of stages) in such a way that it has a somewhat higher torque at very low speeds, and so that it can be run at speeds well above the optimum, as shown by the broken lines.

Test Performance. In view of the good fuel consumption, the question arises as to how it is possible to obtain diesel efficiencies with a plant where the working medium has not only to pass through the diesel engine itself, but also through a compressor and a turbine. The additional losses which this no doubt entails must obviously be compensated in one way or another. In fact, the following is found:

The cooling water loss which in normal diesel amounts to 22 to 25 percent is only 19.4 percent in the present case. This is the result of the small heat absorbing surface in relation to the power output of the highly supercharged cylinder.

The thermal efficiency of the cycle increases with the compression pressure and this can be increased to more than 70 atmospheres in a free-piston engine in the absence of any bearings which must always be considered in ordinary diesel engines. Theoretically, an increase of compression from 40 atmospheres to 60 or 80 atmospheres corresponds to an increase in efficiency of 6 percent or 9.3 percent.

Because bearing friction is absent, the frictional losses are likewise less. In the normal two-stroke engine the frictional losses amount to 20 percent of the effective shaft power. Of this more than half is produced by bearing friction which is avoided in free-piston engines. The piston friction can be calculated on the basis of thorough tests. Thus, for maximum load operation at a working pressure of 3.8 atmosphere gage the power output into gas is 1535 gas hp, corresponding to 1350 hp at the turbine shaft, assuming 88 percent turbine efficiency, with an effective stroke of 462 mm and a speed of 637 cycles per min giving a mean piston speed 9.8 m/s. This gives a total frictional power in the generator of 126 hp, i.e., only 9.3 percent of the effective turbine power. This loss is distributed to approximately 55 percent on the outward stroke and 45 percent on the inward stroke; or 47 percent on the compressor pistons, 33 percent on the engine pistons and 20 percent on the connecting rods. Compared with a normal two-stroke engine this means a savings of frictional loss of 10.7 percent of the effective shaft power.

Features of Coupling Gas-Generator to Turbine. The gas pressure and temperature conditions are very favorable for the turbine in a gas-generator plant. The gas inlet temperature to the turbine is about 500 C, at full load, and is considerably lower than could be used in normal gas turbines with a good efficiency. The pressure range between 5 and 1 atm. abs., on the other hand, corresponds to the most favorable mean pressure zone of a steam turbine plant, and good turbine efficiencies can therefore be expected for moderately large units.

The power output is not controlled by throttling or partial admission as in a steam turbine, but it is done entirely at the gas-generator, varying the gas pressure at the turbine by adjusting the quantity of gas delivered to the requirements of the turbine. The maximum and minimum gas flow which can be supplied by the generator are shown at the inlet to the working pressure at the inlet to the turbine. By taking the gas flow through the turbine from the curve Q_{tu} (Figure 8), at each working pressure, and multiplying this mass flow

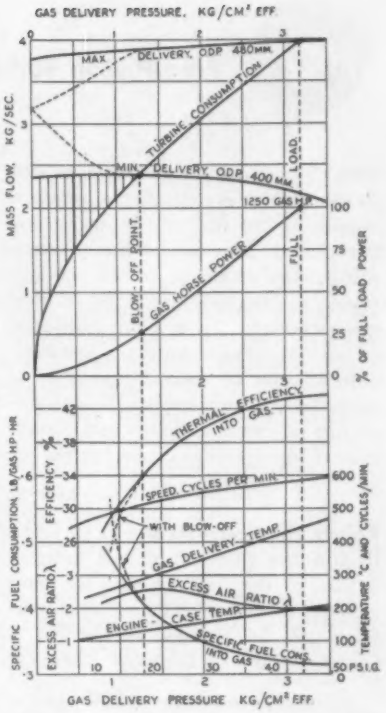


FIGURE 5—Thermal efficiency is highest at full load.

by the heat drop, the curve of power output P_{kl} against working pressure p_vT is readily determined. The range of power output at the terminals of an electric generator is from 110 percent down to 17 percent of full load. The power output of the plant can thus be controlled over this range directly from speed governor of the turbine acting on the fuel pump rack of the gas-generator. For power outputs less than 17 percent with only one gas-generator, part of the gas would have to be blown off.

The gas-generator, being a piston engine, delivers gas in a pulsating

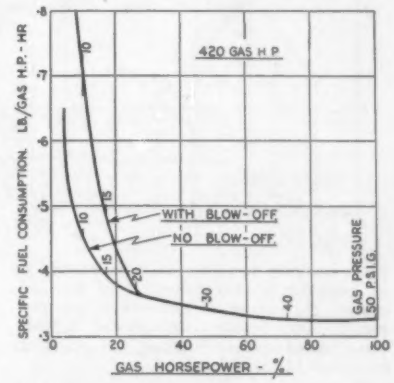


FIGURE 6—Test results show specific fuel consumption is low at high gas horsepower percentages.

flow, but as a constant rate of flow to the turbine is desirable, a means of equalizing the delivery to the turbine is required. This can be done without using large collecting vessels, by supplying the turbine from two or more gas-generators. In a plant consisting of several gas-generators a considerable amount of equalization is to be expected, because even with gas-generators of identical design and equally loaded, the speed in cycles per minute will vary slightly.

Points for Consideration. In Great Britain the petro chemicals industry is leading the way. One of the most interesting plants to come into operation will be installed in the No. 3 Olefines plant of Imperial Chemical Industries Ltd (I.C.I.), Wilton, England. The gas compressors will be driven by several independently controlled gas turbines, supplied with gas from a battery of 15 free-piston gas generators.

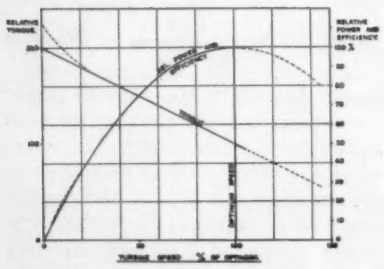
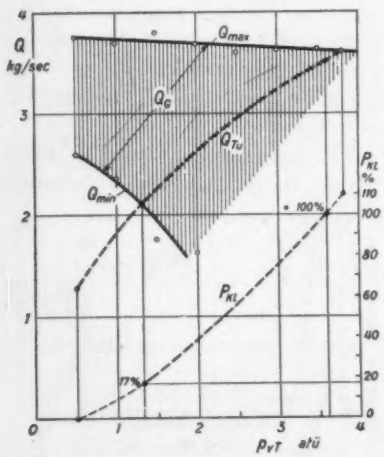


FIGURE 7—Turbine-torque drops as speed, power and efficiency increase.



P_{vT} working pressure at inlet to turbine
Q quantity of gas delivered to gas generator, Q_G range of delivery of gas generator, Q_{Tu} intake capacity of turbine, P_{KI} useful power output of plant at terminals in % of full load.

FIGURE 8—The turbine output is not controlled by throttling, as in steam turbines, but is accomplished by varying the gas pressure.

One company gives the following reasons for a refinery engineer's interest in similar plants:

- In a multi-gas-generator plant, individual gas-generators can be shut down for maintenance without interruption of the operation of the plant as a whole. A proportion of 1 gas-generator in 4 or 1 in 6 is all that need be provided for standby equipment to permit continuous operation of the plant throughout the year. The existing evidence is that no standby turbines are required.

- Owing to the high maximum temperatures and pressures in the diesel cylinder and the large amount of excess air, the free-piston gas-generator is particularly well adapted to burning a wide variety of liquid fuels (including heavy residual oils and crude). The engine is comparatively insensitive to the fuel which may be changed with very little, if any, adjustment to the plant.

- The over-all efficiency, while not perhaps as good as that of the best diesel plant, is good, e.g. 34.8 percent at the alternator terminals on the 6000 KW generating set at Cherbourg, France.

- Owing to the simplicity of construction of the gas-generator and the absence of crankshafts, connecting rods, mechanically operated valve gear etc., the man-hours required for maintenance are appreciably less than in the case of the diesel engine, e.g., the time required to remove the diesel pistons, replace the top piston ring, refit the pistons and start up again, is approximately one hour.

- The exhaust heat can be used to raise process steam at pressures up to 100 psi. without burning additional fuel. Alternatively, since the gas delivered by the gas-generators contains 80 percent unburned air, additional fuel can be burned, either in a pressurized boiler between the gas-generators and the turbines, or in a normal boiler downstream of the turbines. The steam generated can either be used for process work, or for generating additional power, e.g., 8 gas-generators combined with a steam cycle can produce 25,000 KW as compared with 6000 KW on their own. The over-all efficiency of such a mixed cycle set is about 7 percent higher than the efficiency of the steam side.

- Since the two piston assemblies of the free-piston gas-generator are of the same weight and move in opposite directions, there are no out-of-balance forces or vibration, and no heavy foundations are needed. This, combined with the low over-all height of such a plant, tends towards a saving in cost of foundations and buildings.

- It is claimed that under average refinery conditions a plant of several thousand hp would compare favorably with other types of prime movers in this respect.

Each of the points mentioned above has a favorable economic effect and their total influence on the over-all economies of such a plant, especially a continuously operating plant, such as is used in oil refineries or the chemical industry, may be quite marked.

A further point which might appeal to refinery engineers is the possibility of standardization on one type of gas-generator for a wide range of power and applications. This will enable him to reduce the total number of spares to be held in stock; to train his maintenance staff on a single simple type of machine and, if necessary, to move individual gas-generators which weigh only 8 tons per 1000 hp unit from one part of the refinery to another.

ACKNOWLEDGMENT

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What's Required for . . .

Turbine Foundation Design

Here's a review of the principles required for turbine, foundation design with a treatment for design on unstable soil.

William E. Wilbur
The Fluor Corporation, Los Angeles

THE STRUCTURAL designer must base his work on a few well established and fundamental principles. By analyzing these principles, as they apply to the subject at hand, he can arrive at a satisfactory basis for design; and by utilizing the experience that has been accumulated over the years, he can design foundations which will fullfill their purpose.

Foundation Loading. First consider and classify the kinds of loading to which a foundation may be subjected; and secondly, let us take up the means by which the foundation resists the loads.

Standard Loads

1. Dead Load. This is the total weight of the machine and its appurtenances, of any connected piping, of any structural support above the foundation, of the foundation itself, and of any earth resting on the foundation. This is routine for the structural designer, and needs only the determination of the location of each portion of the load, and the arrangement of the base so that the center of gravity of the loads coincides as nearly as possible with the center of gravity of the base.

2. Live Load. Vertical loads, other than dead load, which may be applied. This is rarely of importance in the design of machinery foundations.

3. Impact. An allowance to care for the effect of suddenly applied loads, such as traffic loads on a bridge, or loads picked up by a traveling crane. This is taken as a percentage of the load, and may or may not be considered as carried through to the foundation itself. Some specifications for machinery foundations require that such an allowance, of 100 percent or 200 percent, be used to care for the effect of vibration; but this is hardly logical, since the effect of vibration is not the same as the effect of an additional vertical load.

4. Wind loads, and seismic effects. These may require consideration in the design; but again, they involve no different principles from the routine design, and should cause no difficulty.

Soil Bearing. Since all foundations ultimately rest on the earth, determination of the safe bearing value is of great importance. The natural earth is neither homogeneous nor elastic, and the allowable bearing value to be used is a matter involving many factors.

Within the past few years the subject of soil mechanics has developed rapidly, until now it is possible to predict with reasonable accuracy what will be the behavior of the soil under the loads imposed. The subject is a specialty, however; and it is money well spent to put the investigation into the hands of a consulting soil analyst, who makes the field surveys and tests, and renders his report. This report should show:

- The record of borings made, with the nature and depth of strata encountered.
- Recommended loads which may

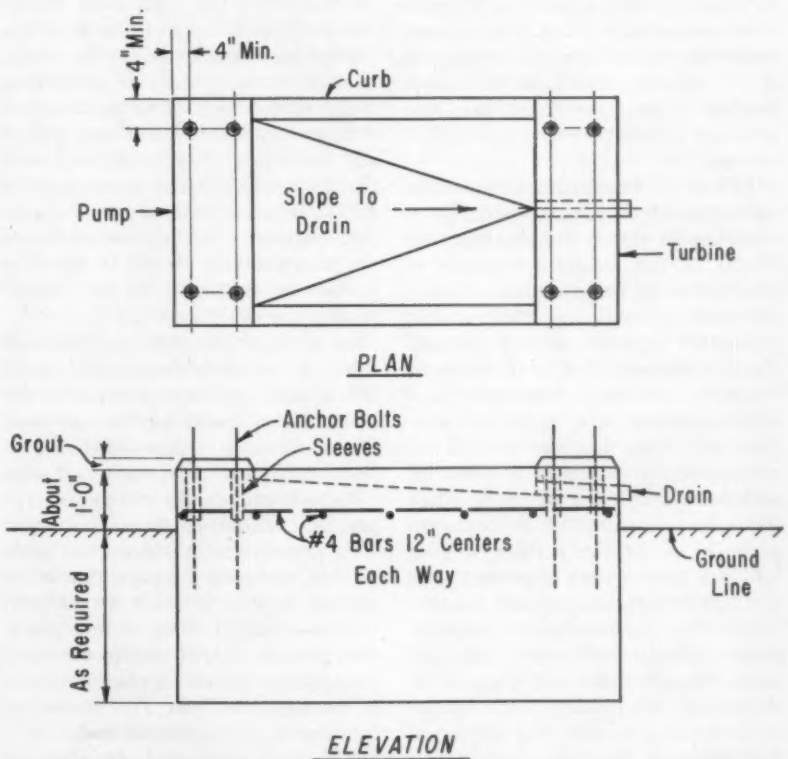

FIGURE 1—Typical turbine and pump foundation has a common base for the turbine and pump.

be placed upon the soil; or, recommended loads and lengths of piling for soft soils.

- Probable settlements of structures under the loads, on the basis of recommended bearing pressures.
- Depth of frost penetration.
- Depth to ground water.
- Recommended minimum depth of footings.
- Value of the soil in resisting lateral loads by passive pressure.

It may be noted that, when a foundation for machinery has been made sufficiently heavy to provide against the results of vibration, it will frequently be found that the bearing has been spread over such a large area as to make the load per square foot much less than the maximum permitted for the soil. The effect of possible settlement must, however, still be considered.

A recent development in foundation practice is that of removing some of the soft top soils, and replacing them with a fill of good material, thoroughly compacted, and tested after completion. When this is done under the supervision and inspection of a competent soil analyst, a good bearing value is obtained, and the resulting foundations are quite satisfactory.

Effects of Temperature. Since the operation of a turbine results in a considerable rise in temperature, the effects of the resulting expansion must be cared for. Expansion within the turbine itself, as affecting the clearances between moving parts, is the problem of the manufacturer. Since the connected equipment, such as a pump, is at a lower temperature, it follows that the vertical expansion of the two units is different, and the alignment is affected. While this effect is small, it is common practice to set the turbine a little low, and to check the alignment after the turbine has come to full temperature. This requires careful preparation of the concrete seats, and provision for adjustment by grouting or shimming. Alternately, some manufacturers now support the turbine at the center of the drive shaft, eliminating this difficulty.

Increase in temperature also causes a horizontal expansion of the turbine, requiring that provision be made for the feet to slide on the foundation. This is accomplished by fixing one end, and using sliding plates under the other. Motion on these plates is resisted by friction due to the weight of the machine. As the machine heats, the expansion force is gradually built up, until it becomes great enough to overcome the friction; at which time sliding occurs, and the horizontal load disappears. This cycle repeats with each major change in temperature. The amount of this friction depends on the smoothness of the plates; a value commonly used is 25 percent of the imposed load. This friction is a horizontal load transmitted to the foundation, in the direction of sliding, and must be cared for; in large turbogenerator units, it becomes of considerable importance.

Pipe Expansion Loads. The expansion of piping from an increase in temperature exerts thrusts and moments on the connected equipment. These forces must be kept low enough so as not to injure the equipment by moving it out of alignment, or by dangerously reducing the close clearances used in centrifugal pumps and turbines. This is, of course, more the concern of the manufacturer of the equipment than of the foundation engineer; and in case of doubt, the manufacturer should be asked to furnish a statement of the maximum permissible loads.[1]

As a rough rule, the total resultant thrust on a nozzle should not exceed 100 pounds per inch of diameter for steel, and somewhat less for cast iron. The total moment imposed should be small enough so that, combined with the dead load, it will not put an appreciable tension on the anchor bolts. It is permissible to reduce the loads by cold-springing the pipe; that is, by making it a little short in the cold condition, and forcing it into place, thus putting thrusts and moments of the opposite nature on the equipment in the cold condition. This is covered by rules of the applicable codes.

The loads mentioned above are, of course, carried into the foundation; but they are usually so small as to be negligible in comparison with the other loads.

Consider the case of a simple reciprocating compressor, as diagrammed in Figure 1.

The drive shaft, acting on the crank of radius r, moves the connecting rod A. This causes the piston, P, to move back and forth in the cylinder, C. The action of the piston compresses gas in the cylinder. The force of this compression is taken by the end wall of the cylinder; and its reaction is provided for in the machine itself; so that there is no load on the foundation from this cause. It does, however, require a considerable force to overcome the inertia of the piston, and to move it back and forth, and this force is not balanced in the machine.

The laws of motion state that a force is required to change the direction or speed of a moving object. This force is equal to the mass times the acceleration. ($F = Ma$.) The mass, M, is the weight in pounds divided by 32.2 (acceleration of gravity, commonly indicated by g). The acceleration, a, is the rate of change of the velocity of motion, in feet per second per second.

The piston, P, makes one complete forward and backward movement for each revolution of the crank. The actual speed is thus constantly changing. The maximum acceleration occurs when the piston is at either end of the stroke, and has a value of

$$a = \frac{\pi^2 \, r \, n^2}{900}$$

where n is the revolutions per minute of the crank, and r is the crank radius, in feet.

It will be seen that this force varies with the square of the speed of the machine, and may therefore become quite large for high speed equipment. The weight to be considered is the weight of all horizontally moving parts, including the piston, connecting rod, and crank pin.

Effects of Moving Parts. All of the loads discussed in the previous paragraphs may be cared for in accordance with the rules for static equilibrium. When moving parts are considered, however, these rules are no longer sufficient.

The turbine is essentially a uniform circular disk, rotating about its center with a uniform speed. For this case, the laws of motion state that a force is required to change the di-

rection of motion of a moving body. In maintaining its uniform circular motion, each particle of a rotating body develops a centrifugal force, tending to pull away from the center. The amount of this force is $Mv^2 \div r$, where M is the mass of the particle, v its circular speed in feet per second, and r is its distance from the center of rotation. In terms of weight and rpm, this becomes

$$F = \frac{W}{g} \frac{\pi^2 r n^2}{900}$$

The formula for this force is the same as for reciprocating motion, but there is this great difference:—the forces in a turbine disk tend to balance each other. If it were possible to build a turbine which was absolutely uniform throughout, the inertia forces would completely cancel out in the machine itself.

Such a condition is not, however, possible; the turbine blades themselves are not uniform, the steam is not applied uniformly about the circumference, and always there is the unbalance due to the friction between shaft and bearings. The inertia forces developed by a turbine are therefore much less than those developed by reciprocating equipment; but they are also very difficult to evaluate. It will also be evident that these unbalanced forces rotate about the center, so that through one revolution they may be said to act successively in all directions; the maximum horizontal effect is the same as the maximum vertical effect.

From a study of the equation above, it is evident that in high speed equipment the inertia force may be many times as great as the weight which causes it; but it must be remembered that the forces are due only to the portions of the machine which are not balanced.

Vibration. Before considering how the inertia forces are resisted by the foundation, it is necessary to understand the important matter of vibration.

The inertia forces deliver a rapid series of hammer blows, as it were, to the machine, and through it to the foundation, going through a complete cycle in one revolution of the machine. This causes a vibration of the machine, of the foundation, and of the soil on which it rests; which has a frequency, commonly designated as "f," equal to the number of revolutions per second of the machine. It is the duty of the foundation, by virtue of its weight and resistance to motion, to dampen this vibration so that its effects will die out in a short distance. The foundation will move, as will the earth on which it rests; but with a properly designed foundation these movements become so small as to be imperceptible.

Every solid body has a natural or fundamental frequency; that is, a frequency at which it will vibrate if set in motion and allowed to vibrate without resistance. The more rigid the body, the greater is its natural frequency. Theoretically, no power is required to maintain vibration at the fundamental frequency, once it has been started. If an attempt is made to cause a body to vibrate at a frequency quite different from its natural frequency, it immediately acts to dampen the motion, and the magnitude of vibration is rapidly reduced. If the impressed frequency approaches the natural frequency, the damping effect becomes less; and if the impressed frequency is equal to the natural frequency, there is no damping effect, and the body vibrates with continually increasing motion, until finally failure may result. This condition is known as resonance.

This is the key to the proper design of foundations for moving equipment. The foundation must have a frequency quite different from that of the machine. Preferably, the frequency of the foundation should be much greater than that of the machine; if it is less, there will be a time as the machine is started up, when the machine will be moving at natural frequency of the foundation.

Fortunately, in a massive concrete foundation such as is normally used for turbines or compressors, the natural frequency is so large that there is no question of possible resonance. The foundation will then act to reduce the vibration. Roughly, the reduction will be in the ratio of the weight resisting motion to the inertia force causing it; for example, an inertia force may be due to a weight rotating on a 5-inch radius; if the total weight resisting motion is 100 times the inertia force, the motion will be reduced to 0.05 inch each way.

In determining the weight resisting motion, we include the weight of the fixed parts of the machine, the complete weight of the concrete foundation and any earth above it, and the weight of the earth under and around the foundation which resists movement. The latter item is quite indefinite; one author[2] states that it averages ten times the weight of the foundation itself.

It is not generally realized that the earth itself may have a natural frequency of vibration. Test results of several types of soils, indicate that frequencies vary from about 10 cycles per second for soft soil, 20 for stiff clay or sand, to 40 for solid rock.[3] Evidently, if the natural frequency of the soil is close to that of the machine, the soil will offer little resistance to vibration, and a heavier foundation is necessary.

Foundation Weight. From the above discussion, it will be evident that there are so many uncertain factors as to make theoretical considerations merely a good guide to the judgment; and recourse must be had to the results of established practices which have proved successful.

For slower, reciprocating machines, it has long been the practice to make the weight of the foundation and the overlying soil equal to five times the total weight of the machine. All manufacturers recommend a minimum yardage of concrete for each machine, based generally on a soil capable of carrying a load of 4000 pounds per square foot. For softer soils, the size of the foundation should be increased. Never should the foundation be smaller than the manufacturer's recommendation.

In this connection, it is well to remember that the cost of a concrete foundation does not increase proportionately with its size. Additional concrete requires very little additional form cost; the placing of the concrete is easier; and the quantity of reinforcing steel may even be reduced. Since a deficient foundation can only be repaired at great difficulty and expense, the use of additional concrete is cheap insurance.

Reciprocating compressors have recently been introduced on the market with designs in which the cylinders oppose each other in pairs, thus practically canceling out the inertia forces. Such compressors have been mounted on skids, and operated successfully on a minimum amount of

foundation. For a permanent installation, however, a foundation weighing at least three times the weight of the machine would be advisable.

Although the formulas for inertia forces for rotating and reciprocating machinery are the same, it must be remembered that the turbine is a nearly balanced machine, so that the portions causing vibration are much smaller, proportionately, than for reciprocating units, although their determination is more difficult. Manufacturers generally recommend that the weight of the foundation shall be at least three times the weight of the rotating equipment, including the pump or other driven equipment as well as the turbine itself.

With the ordinary turbine and pump foundation, this requirement is not difficult to meet. The turbine and pump are mounted on a simple rectangular block, large enough to accommodate the bases of both. This extends about one foot above the ground, and into the ground as required for a firm foundation. When these requirements are met, it will be found that, except for the largest machines, the foundation is of ample size, and the soil bearing is generally low. A typical turbine and pump foundation is shown in Figure 1.

These points are to be emphasized in such a foundation: (1) a common concrete base for the turbine and pump, to eliminate any possibility of change of alignment; (2) a rigid foundation; and (3) a foundation of such size as to avoid the danger of objectionable settlement.

For the large units, such as compressors, the foundations will generally consist of massive blocks built up to support the equipment, and superimposed on a mat, which may spread out over a considerable area. Where several compressors are in line, a common mat for all is good practice; but the total weight is not reduced on that account.

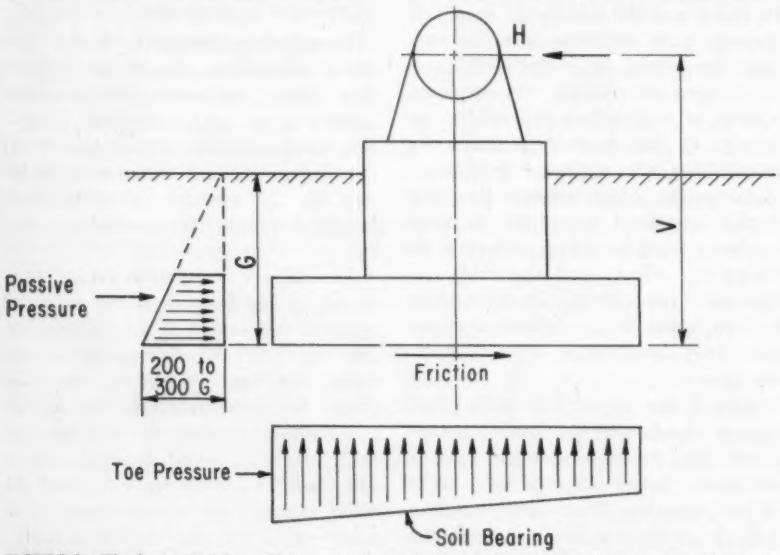

FIGURE 2—The horizontal force H is resisted principally by the friction of the base on the earth.

While formerly it was considered necessary to have the foundations of the building independent of those of the compressors, present practice has changed this idea, and it is now quite common to have the building columns rest on an extension of the mat. In this way, the weight of the building itself acts to stabilize the foundation; and the possibility of objectionable vibration in the building does not appear to be increased.

Horizontal Forces. It was brought out in the discussion above that the motion of the machinery produces large inertia forces in a horizontal direction; and these forces must be resisted by the foundation. For reciprocating machinery, the amount of these forces can be approximated by applying the formula to the known weight of horizontally moving parts; frequently, this information is furnished by the manufacturer. For turbines, the amount of the force can be based only upon experience. It is recommended that the horizontal force be assumed as 25 percent of the weight of rotating parts for the lower speeds, say under 2000 rpm.; and be gradually increased to 100 percent for speeds of about 5000 rpm.

Figure 2 shows the way in which the horizontal force is resisted. The force, H, is delivered at the center of the drive shaft. It is resisted principally by the friction of the base on the earth; if the mat is poured in firm soil, without forms, an additional resistance is provided by the passive pressure of the earth in front of the mat. Normally, however, the friction available is ample for the purpose, since in good soil the earth will develop a frictional resistance of as much as 40 percent of the total weight on it.

The force H produces an overturning moment, of amount HV, on the foundation, which is cared for by a variation in soil bearing, as indicated. The amount of this moment will decrease as the height V is reduced; and the difference in soil pressure between the two edges of the mat will be reduced as the width of the mat is increased. It is considered good practice to proportion the size of the mat so that the maximum soil pressure is not more than 20 percent greater than the average.

Foundations on Piles. When the ground is too soft to support the loads, recourse must be had to a pile foundation. This is, at best, a makeshift; and before deciding on a pile foundation, consideration should be given to the possibility of a large spread footing with low soil bearing; or a footing resting on a carefully compacted fill, as discussed above.

Where a pile foundation is used, the length, type and loading of piles should be determined by the soil analyst. The spacing of piles, center to center, should not be less than 3 diameters, nor less than 3 feet. Wood piles extend 6 inches into the base; concrete piles a minimum of 3 inches.

When piles are used, they are assumed to carry the entire vertical

load; no load is credited to bearing of the base on the soil. The load on the piles will then consist of the entire weight of equipment; of the weight of the concrete foundation and any earth resting on it. For rotating machinery, it is evident that an additional vertical load, equal to the horizontal load, H, should be added.

Authorities do not agree on the manner in which a pile foundation resists horizontal loads. It is certain that vertical piles will take a certain amount of horizontal load in shear and bending; but in order to do this, the piles must have a deflection somewhat as a vertical cantilever. This horizontal movement is what we are trying to avoid in machinery foundations. It seems wise, therefore, in important foundations, to provide batter piles designed to take the horizontal loadings. One or two rows of batter piles may be used along each edge of the footing; and of course, the piles on opposite edges are battered in opposite directions, and only one set is working at one time. The horizontal load resisted by a batter pile is the horizontal component of its total load; the vertical component aids in resisting the vertical load.[4] This statement is a simplification of the true conditions, which are very complicated.

For small foundations, such as for pumps, it is obviously uneconomical to put four piles under each pump. For such cases, a number of pumps may be grouped together on one mat, which then has piling proportioned for the combined loads.

It was noted above that for a footing on soil, a comparatively large body of soil is active in resisting vibration. Since pile foundations are used only when the soil is inadequate to support the loads, it is evident that this effect will be greatly reduced for a footing on piles; hence these foundations should be generously proportioned both as to the weight of the foundation itself, and as to the capacity of the piles to take the load.

Turbo-Generator Foundations. A turbo-generator generally rests on a frame of concrete (sometimes steel, or steel encased in concrete), 15 to 20 feet above the top of the mat. The adjacent floor is completely separated from the equipment support, in order that no vibration be transmitted; but it is permissible to support the floor columns on the main mat.

The concrete frame, exclusive of the mat, should weigh from 1½ to 2½ times the weight of the equipment. It should be as rigid as possible; manufacturers specify maximum deflections of the nature of 0.02 inch for any combination of loads which may occur. Cantilevers should be avoided, on account of their great deflections. It is good practice to make the concrete beams and columns as large as the available space and clearances will permit; and to connect them by liberal haunches.[5]

Emphasis is placed on eliminating the possibility of resonance, by proportioning the frame, and each component of it, to have a natural frequency quite different from that of the machine.

Installations of turbine-blower or turbine-compressor combinations, in which the equipment is placed at a floor level above the supporting mat, will follow the same general principles as outlined above for turbo-generators.

Fundamental Frequency. As stated above, each beam, or portion of a frame, has a natural or fundamental frequency at which it tends to vibrate.

For the case of a concentrated load, P, at the center of a simply supported beam, or of a beam with rigidly fixed ends, or at the free end of a cantilever, the frequency is given by the expression $f = 3.127 \div \sqrt{d}$ where f is the frequency in cycles per second, and d is the deflection in inches due to the load. d has the following values (units are inches and pounds):

For a simple beam, $d = PL^3 \div 48\ EI$.
For a fixed beam, $d = PL^3 \div 192\ EI$.
For a cantilever, $d = PL^3 \div 3\ EI$.

Neglecting the weight of the beam, then, the frequency for a fixed beam is twice that for a simply supported beam; for a cantilever, it is ¼ of that for a simply supported beam. Accounting for the weight of the beam changes these results; it is sufficiently accurate to assume that the load P is increased by the following fractions of the total weight of the beam:

Simple beam, 17/35; fixed beam, 13/35; cantilever, 33/140.

It is seen that the frequency becomes smaller as the load is increased; but increases rapidly as the beam is made more rigid.

It is not difficult to apply the above expressions to steel beams. For concrete, however, the case is different, since the following questions arise: (1) What should be taken as the value of the moment of inertia of a concrete beam? (2) On what basis is the length of span determined? (3) What degree of restraint is effective at the ends? (4) How do the haunches affect the results? It is evident that these uncertainties will make the result of the calculations only as good as the judgment of the designer, and precision is not to be expected. Again, a good rule is "Don't spare the concrete; make the structure as rigid as possible."[6]

Progress has been made in dampening or controlling vibrations by the use of springs or by introduction of resilient layers (such as cork or felt). These special cases, which are not discussed here, are discussed in References 2 and 3.

About the Author

WILLIAM E. WILBUR is structural engineer for the Estimating department, Fluor Corp., Ltd., Los Angeles, has spent most of his career in bridge and refinery construction. Associated with a Kansas City firm of bridge builders for 14 years before he joined the Fluor organization in 1942, he has filled two 250-page notebooks with the answers to the problems he has faced in structural engineering. A licensed engineer in Illinois, Missouri, and Kansas, Wilbur is a 1911 civil engineering graduate of Iowa State College, and a life-member of ASCE.

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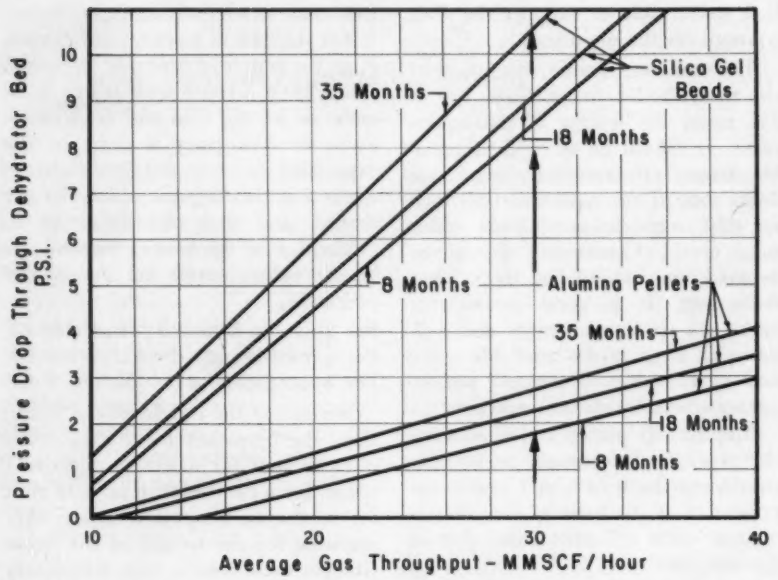


FIGURE 1—Pressure drop comparison for two desiccants for various throughputs. Notice the increase in pressure drop with age of usage.

First Report From Gabe On Desiccant Performance

TGT's dehydrators at Gabe extraction plant require rugged desiccants. Here's how several types performed in five years of operation.

A. G. Harrell
Tennessee Gas Transmission Company, Greensburg, Ky.

TO OPERATE THE refrigerated extraction plant at Gabe, Ky., TGT must remove all moisture from the incoming gas stream before cooling the feed to —105 F. To do this, TGT uses 16 dehydrators containing a total of 260 tons of desiccants. Here's what TGT has learned about performance of various desiccants and how they solved the fouling problem.

Dew Point Requirements—The incoming feed gas stream (950,000 MCF) to the plant contains a maximum of seven pounds of water per million cubic feet at 72 F and 570 psig. Since the entire stream is chilled to minus 105 F, all moisture must be removed to prevent icing of heat exchangers.

Dehydration Installation—The plant feed wet gas stream enters eight scrubbers with mist extractors to remove free water or other entrained liquids before entering the dryers. Sixteen dehydrators operating in parallel are provided to process the 950,000 MCF daily. Fourteen are generally on stream at one time while one is being reactivated and another cooling. Each dehydrator, six feet six inches in diameter, contains a twenty foot-deep bed of solid desiccant. Down-flow of wet gas stream through drying cycle provides for dry gas to depart from bottom section of dehydrators and enter common header. The dry gas is then divided into five metered streams flowing through the five trains of heat exchangers for chilling.

The re-activation gas stream is procured from upstream of dehydrators and flows parallel through two gas fired vertical furnaces before entering a dehydrator for removal of adsorbed moisture and heavy hydrocarbons. The enriched stream then passes through heat exchangers to a separator. Gas from the separator enters compressors with residual gas from the trains and is transmitted to the main pipeline system. The water from separator is trapped off and liquid hydrocarbon is pumped into de-methanizer bottoms stream.

The cooling gas stream is also procured from upstream of dehydrators and removes heat from a re-activated bed then through heat exchangers to compressor suction for return to main pipeline system.

Experience With Various Desiccants—The first desiccant used was alumina granules 4 to 8 mesh with an apparent density of 50 pounds per cubic foot.

Activated bauxite was purchased later for trial service in a few towers. This desiccant was also 4 to 8 mesh and has an apparent density of 50 pounds per cubic foot.

Silica gel bead has been and is presently in service as a desiccant in several towers. As a matter of fact, three dehydrator units have been in service three years and eight months as of this date with this material four to eight mesh, approximately 50 pounds per cubic foot.

Alumina pellet four to eight mesh (52 to 55 pounds per cubic foot is in

PROCESS FOR REFRIGERATED PLANT

The entire gas stream is chilled to minus 105 F. at 530 psig. Upwards of 1,100,000 gallons of liquid hydrocarbons are recovered each 24 hours at this point. Two flash operations follow with reduction of pressure to 175, then to 55. Final liquid recovery after de-methanizing is 440,000 gallons daily with a peak of 475,000 gallons daily of ethane and heavier hydrocarbons.

The residual gas stream at minus 105 F. is warmed by exchanging heat with the incoming gas, thence flows to compressors. Six 1760 hp and one 2200 hp (total 12,760 hp) gas driven units return the residual gas stream and first flash gas to TGT's main pipe line transmission system at 590 psig. The second flash gas is utilized as fuel.

A conventional ethane-propane cascade-type refrigeration system is employed to provide low level refrigeration. Under this system, ethane is liquified with propane refrigerant while propane is condensed with cooling water. Seven 1760 hp and one 2200 hp (total 14,520 hp) gas driven units process propane and ethane vapor through separate closed systems.

For more details on plant design, see Petroleum Refiner, March, 1952, pg 118.

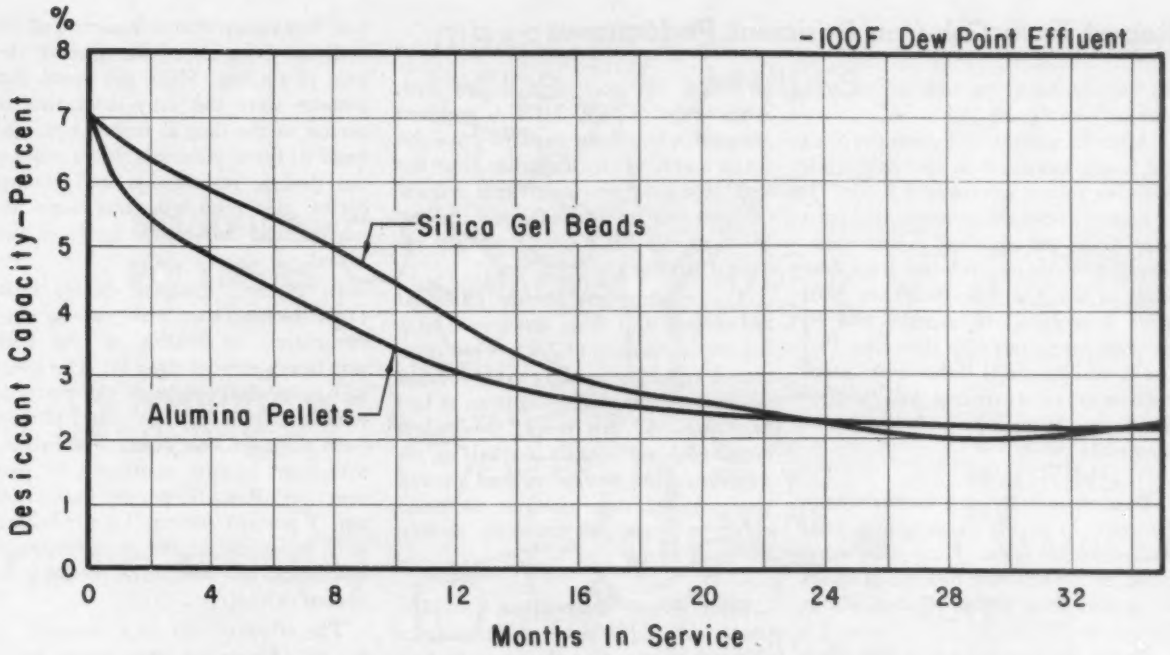


FIGURE 2—Desiccant capacity of the two under comparison showing the drop in capacity with age. Notice how closely they compare after 20 months service.

service in three towers. This desiccant (three years service) is still under observation.

Of the four above mentioned desiccants, the latter two silica bead and alumina pellet are considered most favorable to requirements of this operation at the moment.

A fifth desiccant, silica gel, three to eight mesh, apparent density of 45 pounds per cubic foot, was installed in four towers this month. Observations and operational data will be recorded periodically to determine its efficiency.

Approximately 260 tons of desiccant are required to charge the 16 dehydrators. For this reason, it is imperative to continually seek a material with higher percent drying capacity resulting in less reactivation. The optimum desiccant has not been discovered as yet so far as removing all moisture is concerned for several years of operation.

Superficial Velocities and Pressure Drops—The superficial velocity of the gas stream through the drying cycle varies from 35 to 40 feet per minute depending whether 13 or 14 towers are operating concurrently.

Figure 1 presents a comparison of silica gel beads and alumina pellets after 8, 18 and 35 months installation. This figure indicates 8.5 psig pressure drop through the silica gel bead bed, normal pressure and flow rate three million SCF per hour. Under the same test conditions, 1.8 psig pressure drop was observed on alumina pellet.

The silica gel bead pressure drop had increased to nine psig while alumina pellets increased to 2.6 psig in

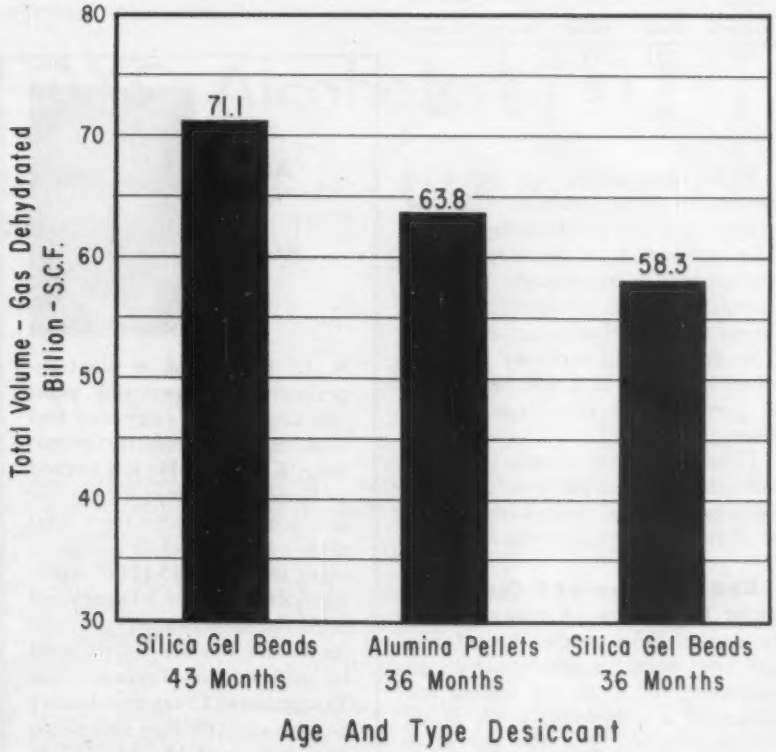


FIGURE 3—Comparison of the volume capacity for the two desiccants. Notice that silica gel beads are slightly better than alumina pellets.

18 months based on similar test conditions (see Figure 1).

After 35 months operation the silica gel beads increased to 10.5 psig while alumina pellets advanced 2.9 psig.

Figure 1 clearly demonstrates pressure drops on silica gel beads under identical pressure, velocity and flow rates of three million SCF per hour after 8 months, 18 months and 35 months operation. Also shown on Figure 1 are identical data under same conditions of alumina pellets after 8 months, 18 months and 35 months operation.

Decrease in Drying Capacities—Decrease in drying capacities of solid desiccants at Gabe Plant has been rapid in the first few months of operation and then begins to level off as indicated (Figure 2).

Shown in Figure 2 are actual comparisons of silica gel bead and alumina pellets under identical operating conditions and drying capacities. Both desiccants had capacities of 7 percent immediately after installation.

Age of Desiccant in Months	Percent Capacity		Number of Reactivations	
	Silica gel Beads	Alumina Pellets	Silica gel Beads	Alumina Pellets
0	7.0	7.0	1	1
8	5.0	3.9	145	145
18	2.7	2.5	272	283
27	2.0	2.2	425	436
35	2.2	2.1	587	598

These observations are based on removal of seven pounds of water per million cubic feet to a bone dry stream. The acceleration of decrease in drying capacity is exceedingly high the first few months of operation then begins to level off to a certain extent. This demands an economy study of when to dispose of a desiccant, when to purchase and what type to purchase.

Figure 3 records volumes processed through the silica gel bead and alumina pellets from time of installation to three full years of operation.

Reactivation and Cooling of Solid Desiccants—A stream of incoming gas flows parallel through two gas fired furnaces and is heated to guarantee 400 F at the bottom entrance of a dehydrator made ready for reactivation. The hot gas flows upward at a superficial velocity of 5.7 feet per minute until 375 F is observed at the top of desiccant bed. An average of 1650 MCF is required through a four hour cycle to drive the water and heavy hydrocarbon from the bed. Hot gas from reactivated bed exchanges heat with stream to furnaces. Even so, 10 MCF per hour are required for fuel.

The cooling gas stream enters at top of bed and flows downward at a superficial velocity of 7.6 feet per minute. A two hour cooling cycle reduces the bed temperature at bottom of bed to 100 F. At this point, the bed is considered sufficiently cooled to return to drying service on feed stream. One million, one hundred thousand cubic feet produces necessary cooling for each cycle.

Pilot Plant Operation—A pilot plant was used to determine the major source and material that was fouling the desiccant beds, also an economical method to avoid re-occurrence. A small pilot plant composed of three test dehydrators and two pre-contactors was designed in such a manner that the three test dehydrators would nearly simulate the top one third of the plant desiccant beds. This was done because preliminary investigation had shown that this portion of the bed had experienced the greatest degree of fouling. Silica gel beads and bauxite were the only desiccants in service at the time so testing was confined to those materials. After numerous drying, reactivation and cooling cycles, the test desiccants were removed and laboratory analyses followed.

In general, analyses clearly indicated the major material causing contamination or fouling of the beds was heavy ends of light oil. The average molecular weight of the material removed from bauxite was 245 and from silica gel beads 289. The extraction from bauxite contained 87 percent paraffins, 12 percent aromatics and 1 percent olefins. This indicated only 1 percent of the material could readily be polymerized if proper conditions existed.

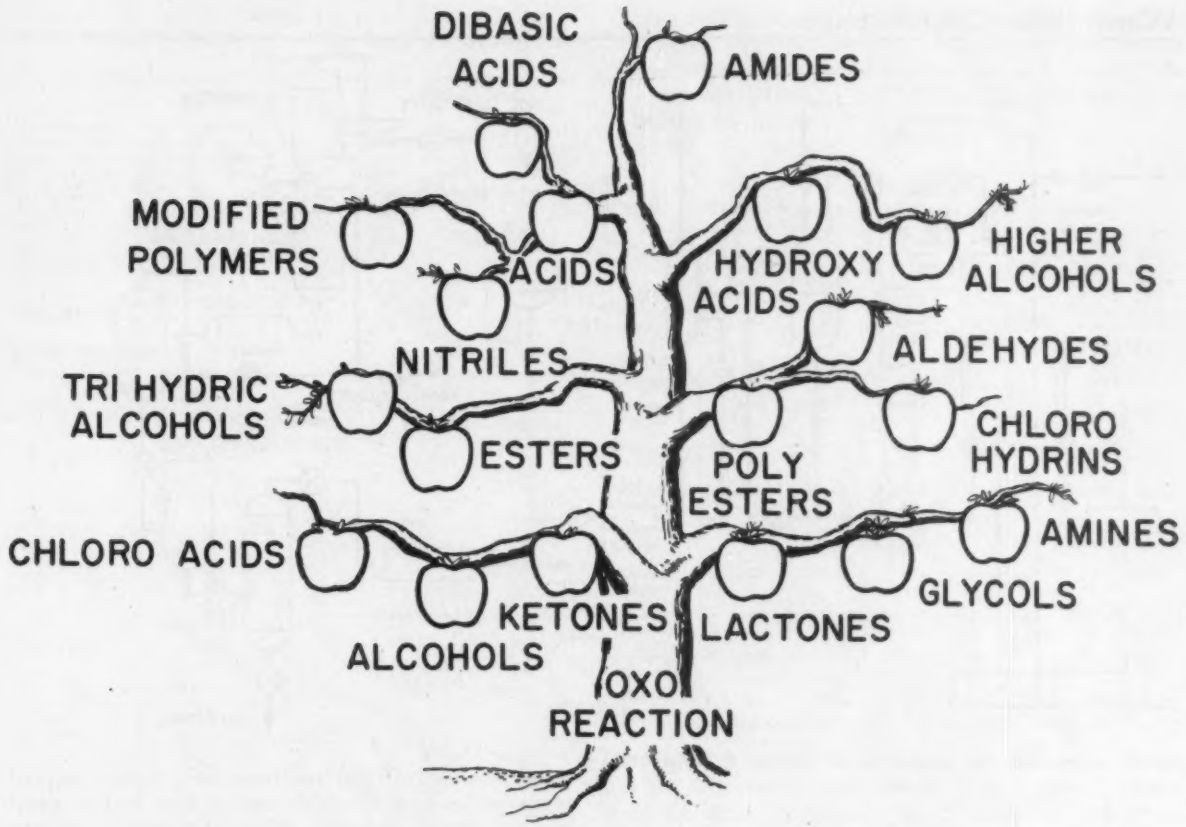
The effect of this oil is two fold. It not only blocks the pores of the desiccant closing off channels for water to enter but also covers the surface of the desiccant making it more difficult for water to reach the desiccant surface thereby slowing adsorption rate. This fouling may also contribute to a slight increase in pressure drop through the beds.

At the time of pilot plant investigation, Tennessee Gas Transmission used scrubber oil to scrub the incoming gas stream to most of the compressor stations. Since several of the stations are upstream of Gabe Plant, a minute quantity of scrubber oil as well as lubricating oil is carried in the gas stream. The intake scrubbers at Gabe cannot remove all of it, therefore, after processing several billion cubic feet of gas, a certain amount of fouling the desiccant is to be expected. Normal reactivation temperatures only remove part of the oil. The use of scrubber oil is no longer necessary at most stations so the problem has been partially eliminated the past two and one-half years.

Other samples procured from compressor valves containing deposits were observed. A considerable amount of this foreign matter was found to be bauxite. Dust from the bauxite was carried by the gas stream through the trains of exchangers and into the compressor cylinders. Some of it remained in the exchangers thereby decreasing heat exchange efficiency. Excess wear in compressor cylinders was also observed. ##

About the Author

A. G. HARRELL is plant superintendent, supervising plant operations for Tennessee Gas Transmission Company, Greensburg, Kentucky. He has worked as laborer, compressor operator and process operator for a total of 6 years, as chief operator, plant foreman and plant superintendent for over 20 years and as division personnel manager for 3 years. For the past six years he has been with Tennessee Gas Transmission Company. Earlier he was with Phillips Petroleum Company, and Humble Oil & Refining Company.



The prolific OXO tree.

Watch These OXO Alcohols*

Ease of manufacture and growing demand will make production of these higher alcohols exceed 100 million pounds during 1957.

Lewis F. Hatch, Contributing Editor
Petroleum Refiiner

J. P. Thorn and E. J. Wickson
Enjay Laboratories, Linden, N. J.

THE DISCOVERY of an entirely new synthetic method for the production of valuable chemicals is a rare event, usually followed by many research papers from academic laboratories. In this respect the oxo reaction is unique, for it has received comparatively little public attention outside of the patent literature and general review articles.[1a] However, industrial research on the reaction and development of product applications have been extensive.

Industrial interest in the oxo reaction and the rapid growth of oxo chemicals since their introduction is natural because they stem from readily available olefins, carbon monoxide and hydrogen.

$$RCH=CH_2 + CO + H_2 \rightarrow RCH_2CH_2CHO$$

Generally, the aldehydes are hydrogenated to give the more valuable primary alcohols.

$$RCH_2CH_2CHO + H_2 \rightarrow RCH_2CH_2CH_2OH$$

The various factors affecting these reactions have been discussed recently by Hughes and Kirshenbaum.[2] Figure 1 represents a typical oxo process.

Oxo chemicals can be divided conveniently into the

* Presented in part by J. P. Thorn and E. J. Wickson at the 131st meeting of the American Chemical Society, Miami, April, 1957.

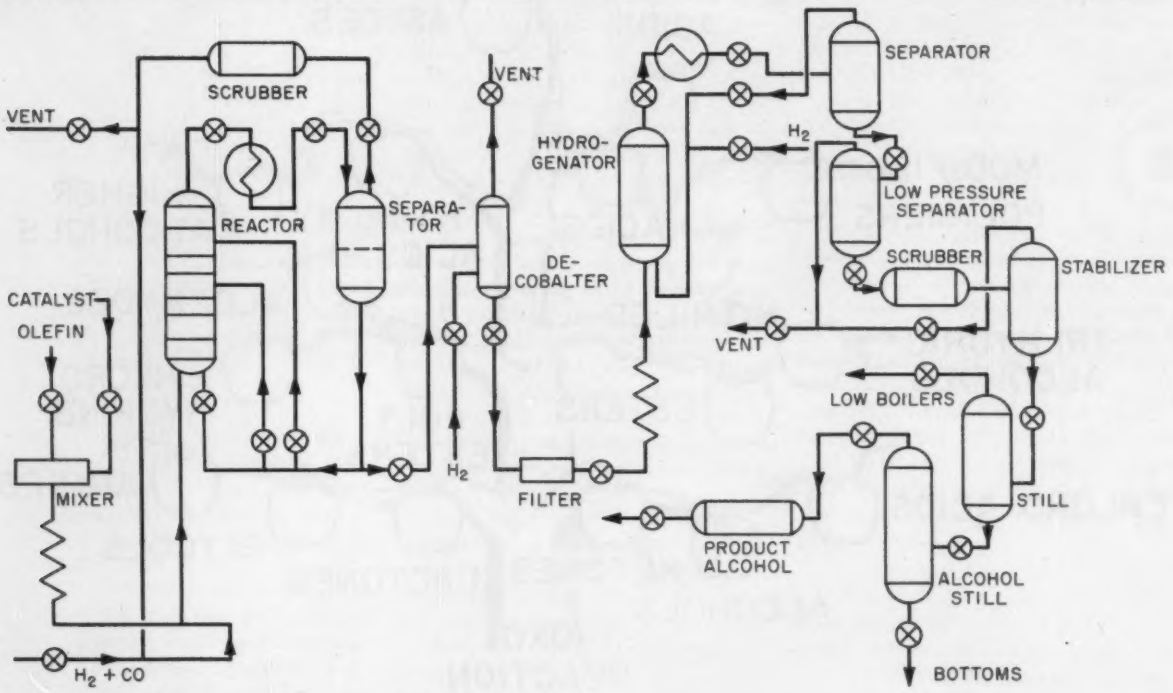


FIGURE 1—Schematic flow diagram for the synthesis of higher OXO alcohols.

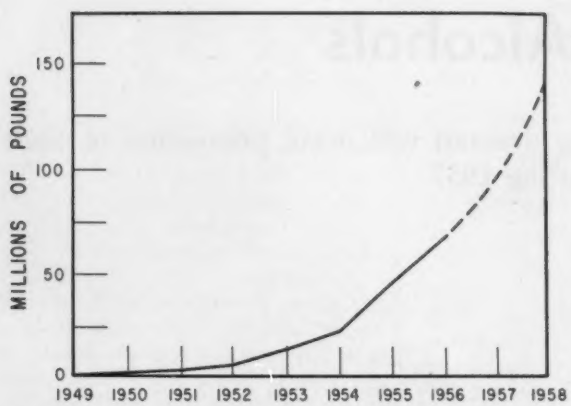


FIGURE 2—Estimated annual production of higher OXO alcohols.

lower molecular weight aldehydes and alcohols (C_3, C_4 and C_5) and the higher oxo alcohols (C_8, C_{10} and C_{13}). The lower oxo aldehydes and alcohols have been available to the chemical industry from other sources and their use patterns are well established. In the short period of time that the higher oxo alcohols have been available they have achieved a high degree of commercial success. Their principal uses are as intermediates for a number of products such as plasticizers, detergents and wetting agents and agricultural chemicals. Figure 2 illustrates the rapid growth of the higher oxo alcohols and gives a prediction of their future growth.[16]

These higher alcohols are obtained by oxonating mixtures of C_7, C_9 or C_{12} olefins. The heptenes are produced by the codimerization of propylene and butylenes. The tripropylenes and tetrapropylenes are obtained by conventional phosphoric acid catalyzed polymerization of propylene. Typical olefin type distribution of these olefins is given in Table 1.

TABLE 1

Olefin Type Distribution of Typical Oxo Feed Stock

Type	Structure	VOLUME PERCENT		
		Heptene	Tripropylene	Tetrapropylene
I	$RCH = CH_2$	1	1	2
II	$RCH = CHR$	12	14	10
III	$R_2C = CH_2$	11	8	7
IV	$R_2C = CHR$	54	35	26
V	$R_2C = CR_2$	22	42	55

The higher oxo alcohols are mixtures of isomers which are not separated into individual compounds. However, the commercial mixtures are remarkably uniform in their physical properties (Table 2), and it is customary to use the alcohol name as a collective noun. The isomer distribution of a typical isooctyl alcohol (C_8) is

3,4-dimethyl-1-hexanol	20 percent
3,5-dimethyl-1-hexanol	30 percent

TABLE 2

General Physical Properties of Isooctyl, Decyl and Tridecyl Oxo Alcohols

CONSTANT	ALCOHOL		
	Isooctyl	Decyl	Tridecyl
Boiling Range, Initial to Dry Point, C.	185–190	215–222	253–270
Refractive Index, n_D^{20C}	1.4308	1.4390	1.4475
Specific Gravity, 20/20 C.	0.8315	0.8370	0.8454
Pour Point, F.	<—95	<—95	<—95
Flash Point, Tag Open Cup, F.	>180	210	245
Coefficient of Expansion per°C.	0.000814	.....	.....
Surface Tension, at 20 C., dynes/cm.	29.5	30.4	30.7
Specific Heat (50-150 C.), cal./g./°C.	0.79	.....	.....
Solubility in Water, g./100 g.:			
25 C.	0.06	<0.05	<0.05
50 C.	0.08	<0.05	<0.05

VAPOR PRESSURE

TEMPERATURE		PRESSURE, mm. Hg		
C.	F.	Isooctyl	Decyl	Tridecyl
50	122	1.95	....	....
75	167	8.4	2.1	....
90	194	....	....	1.3
100	212	30	8.4	2.2
125	257	94	28.2	7.8
150	302	250	82	24
175	347	600	225	64
180	356	700	....	....
200	392	....	500	155
225	437	....	....	340
250	491	....	....	685

VISCOSITY

TEMPERATURE		CENTIPOISES		
99	210	....	1.76	2.61
37.8	100	6.4	....	....
20	68	12.7	21	47.5
— 9.4	15	51.3	115	382.2
—17.8	0	84.4	209.5	808.3
—31.7	—25	224.2	701.3	3692
—40.0	—40	....	1649	11,081
—53.9	—65	....	8826	95,433

4,5-dimethyl-1-hexanol	30 percent
3-methyl-1-heptanol and 5-methyl-1-heptanol	15 percent
Unidentified alcohols	5 percent

Decyl alcohol (C_{10}) consists predominantly of trimethylheptanols and tridecyl alcohol (C_{13}) contains a high percent of tetramethylheptanols.

Isooctyl, decyl and tridecyl alcohols are clear, colorless, slightly viscous liquids having a characteristic alcohol odor. They are soluble in all the common solvents and essentially insoluble in water. Being mixtures of primary alcohols, they will undergo all chemical reactions common to alcohols of this type.

APPLICATIONS

Poly (vinyl chloride) Plasticizers. Many of the modern plastics are based on high molecular weight resins which are hard and often brittle. They are difficult to process and seldom provide the desired characteristics that make them useful for the thousand and one applications for which finished plastics are used. The resin or polymer molecules are bound lengthwise by strong chemical bonds. Laterally, they are bound by relatively weak physical bonds—Van der Wall's forces. The effect of these weaker bonds can be neutralized by the use of plasticizers. Plasticizers are the key that makes plastics "plastic."

Progress in poly (vinyl chloride), *PVC*, compounding during the last decade has been marked by a shift to higher boiling plasticizers. This change to higher molecular weight materials was made necessary by demands for lower volatility with minimum sacrifice in efficiency. The advent and increasing use of vinyl plastisols also made demands for higher boiling plasticizers.

TABLE 3

Physical Properties of Isooctyl and Decyl Esters

ESTER	Refractive Index n_D^{20C}	Specific Gravity 20/20 C.	Boiling Range C.	Flash Point Open Cup F.	Fire Point F.	Pour Point F.	Visc. Centistokes 20 C.
Diisooctyl Phthalate	1.4860	0.9839	230–238 (4.0 mm.)	435	470	—50	80
Didecyl Phthalate	1.4850	0.9674	203–206 (0.4 mm.)	460	....	—50	121.5
Diisooctyl Adipate	1.4480	0.9271	215–220 (4.0 mm.)	420	460	<—75	15.8
Didecyl Adipate	1.4512	0.9177	176–183 (0.5 mm.)	455	500	<—75	29.8
Diisooctyl Azelate	1.4498	0.9204	182–191 (0.2 mm.)	450	495	<—75	24.40
Didecyl Azelate	1.4533	0.9150	210–220 (0.5 mm.)	445	520	<—75	42.2
Diisooctyl Sebacate	1.4480	0.9151	172–174 (0.07 mm.)	435	485	—65	22.3
Didecyl Sebacate	1.4540	0.9080	221–225 (0.5 mm.)	440	525	<—75	42.2
Triisooctyl Phosphate	1.4440	0.9271	198–218 (4.0 mm.)	425	....	<—75	17.1
Didecyl Diglycolate	.....	0.9494	174–178 (0.2 mm.)	440	....	—60	49.9

Immediately following World War II, the C_8 alcohol esters became dominant in the *PVC* plasticizer field and at present this is the largest single use for both isooctyl and decyl alcohols. Diisooctyl (*DIOP*) and didecyl phthalates (*DDP*) are the most important and have a good balance between plasticizer efficiency and volatility. The physical properties of these and other esters are in Table 3.

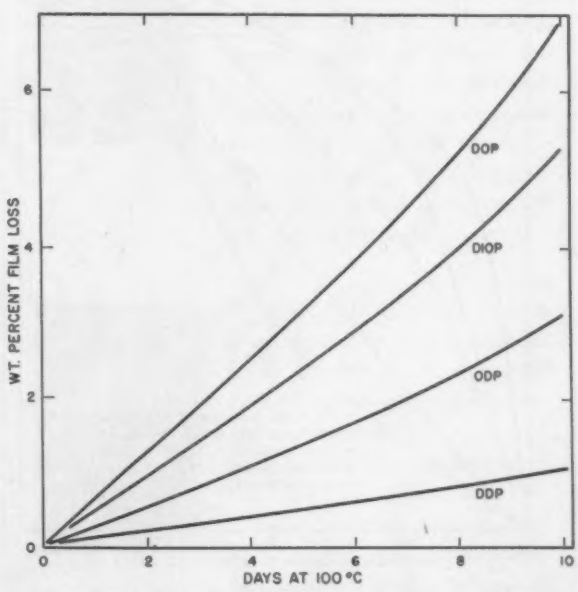


FIGURE 3—Volatility data for OXO phthalate-vinyl compositions. These data were obtained on 75 millimeter film, aged in a circulating air oven at 212°F.

Volatility data are presented in Figure 3. These data were obtained on 75 mil film aged in a circulating air oven at 100 C. for several days. *DIOP* is a standard ester which gives excellent performance under a wide variety of practical applications. *DDP* is much more permanent and is used where its low volatility is an important factor in the choice of plasticizer. Coesters, such as isooctyl decyl phthalate *(ODP)*, or blends of the diesters have intermediate properties and may be used to obtain an optimum balance. A nonoxo ester *(DOP)* is also included for comparison.

Detergents and Wetting Agents. The higher oxo alcohols are important raw materials for the production of both nonionic and anionic detergents and wetting agents. Ethylene oxide reacts with isooctyl, decyl and tridecyl alcohols to form alkyl polyoxyethylene ethanols of any desired molecular weight. These materials are interesting as nonionic water soluble surface active agents. The ethylene oxide adducts of tridecyl alcohol are especially well suited for use as household and industrial detergents. The oxo alcohols react with sulfuric acid or chlorosulfonic acid to produce sulfates. Sodium tridecyl sulfate is an interesting anionic detergent. Both the nonionic and anionic detergents can be "built" in the same manner as other currently available detergents.

Each surface active agent has distinct or characteristic properties. The choice of detergent is governed by the specific requirement or condition under which it is to be used, and test data are helpful in choosing the most effective material. Performance tests show that the nonionic and anionic surface active agents from tridecyl alcohol compare favorable with other commercial surface active agents in wetting, foaming and detergency properties.

Good *wetting* characteristics are generally associated with low surface tension values. The surface tension data plotted in Figure 4 show that tridecyl alcohol nonionics exhibit good surface tension lowering at all concentrations from 0.001 to 1.0 percent. Sodium tridecyl sulfate is similar to sodium lauryl sulfate in that it shows considerably less surface tension lowering below about 0.1 percent.

The significance of *foaming* action of surfactants depends on the desired application. The quantity and stability of lather may be esthetic in a shampoo, but nevertheless desirable. On the other hand, low sudsing is essential in certain automatic washing machines. Sodium tridecyl sulfate produces a good volume of stable foam at concentrations of 0.05 percent or higher in hard water. The nonionic detergent containing 9.6 moles of ethylene oxide per mole of alcohol produces a large volume of foam which is not as stable as that obtained with the sulfate. Lower ethylene oxide ratios give considerably less foam.

Relative *detergency* ratings are given in Table 4. The higher mole ratio nonionics are better than both the anionics. Redeposition is negligible for all these detergents.

Recently surface active agents have been developed in which an alcohol-ethylene oxide condensate is sulfated.[3] Sodium tridecyl polyoxyethylene sulfate is an example of this new type of agent.

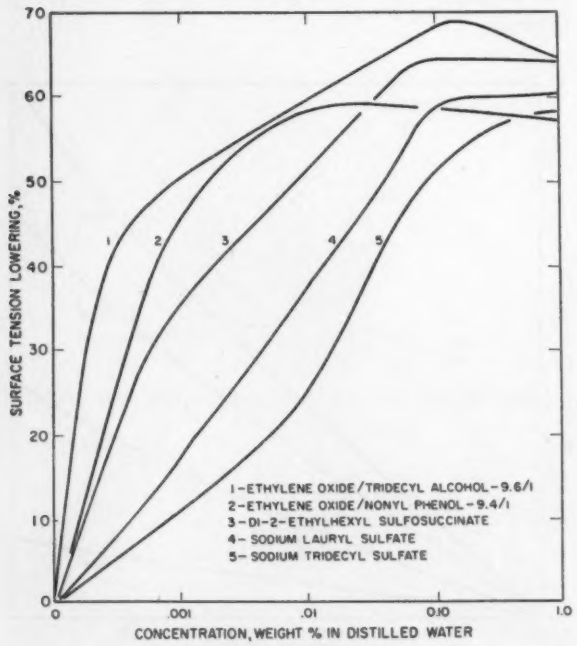


FIGURE 4—Surface tension data plotted above show that tridecyl alcohol nonionics exhibit good surface tension lowering at all concentrations from 0. 0.001 to 1.0 percent.

TABLE 4

Relative Detergency of Tridecyl Alcohol Derivatives

DETERGENT (a)	Mole Ratio (b)	Relative Soil Removal At Indicated Hardness (c)	
		360 PPM	45 PPM
Ethylene Oxide—Tridecyl Alcohol.....	9.6:1	100	100
Ethylene Oxide—Tridecyl Alcohol.....	8.5:1	92	88
Ethylene Oxide—Tridecyl Alcohol.....	11.8:1	79	89
Sodium Lauryl Sulfate.....	.....	78	66
Sodium Tridecyl Sulfate.....	.....	67	38
Ethylene Oxide—Tridecyl Alcohol.....	6.8:1	46	51

(a) 0.15 percent active ingredient concentration.
(b) Moles of ethylene oxide per mole of tridecyl alcohol.
(c) Water hardness made up of a 4/1 mole ratio of calcium/magnesium as the chloride salts. This ratio corresponds to the approximate average ratio in most water. (ASTM D-1126-50T).

Rubber Modifiers. Mercaptans are used in the production of *SBR* rubber as modifiers to control polymer molecular weight. Dodecyl mercaptan *(DDM)*, prepared from mixed coconut alcohols, has been used in large volume for this purpose. There has been interest in the use of tridecyl mercaptan *(TDM)* prepared from low cost tridecyl alcohol. In addition to the economic incentive, the ready availability of the oxo alcohol compared to coconut alcohols can be an important factor in times of national emergency.

Tridecyl mercaptan can be prepared by a two-stage

process involving conversion of the alcohol to the halide followed by reaction of the halide with sodium hydrogen sulfide to form the mercaptan.

Herbicidal Esters. The esters of 2,4-dichlorophenoxyacetic acid *(2,4-D)* and 2,4,5-trichlorophenoxyacetic acid *(2,4,5-T)* have been widely used to destroy selectively broad leaf and woody plants without injury to grasses. The common esters, such as ethyl, propyl and butyl, have the disadvantage of relatively high volatility. This property leads to "drift" from treated fields to nearby susceptible crops. To overcome this disadvantage, higher molecular weight esters have become important.[4, 5, 6] Based upon acid equivalents, these esters have herbicidal activity equal to the lower molecular weight esters.

Oxo alcohol herbicidal esters show that they have significantly lower vapor toxicity than the isopropyl ester.

Ester	Relative Vapor Toxicity
Isopropyl *2,4-D*	5.8
Decyl *2,4-D*	2.0
Isooctyl *2,4-D*	1.9
Tridecyl *2,4-D*	1.4
Decyl *2,4,5-T*	1.3
Tridecyl *2,4,5-T*	1.3
Control (no ester)	1.0

The herbicidal activity of these compounds has been determined both in the laboratory and in the field. The results indicated that the oxo esters were equivalent to the other currently available esters and salts. The *2,4-D* esters were superior to the *2,4,5-T* esters.

The higher oxo alcohol esters are very effective for weed control in both pre-emergence and postemergence treatment. In general, as the molecular weight of the alcohol increases, the activity decreases and as molecular weight increases, the degree of neighboring crop injury decreases, most noticeable in postemergence treatment. Thus, it is possible for a formulator to build a herbicide of a desired activity and degree of crop injury to fit his needs.

Synthetic Lubricants. The advent of the turbo-jet and turbo-prop engines has introduced new lubrication requirements which could not be met with conventional mineral oils. Synthetic lubricants have been developed which have excellent viscosity-temperature properties and inherently high load carrying capacity even at very low viscosity levels. Dicarboxylic acid esters of the oxo alcohols are especially adapted to these requirements.[7]

Lubricant Additives. Lubricants may be subjected at times to extremely heavy pressures in certain critical applications such as hypoid gears. Under these conditions, if the film of lubricating oil fails, the surfaces of the opposed elements contact each other directly with resultant seizure or excessive wear. Higher oxo alcohol phosphates are especially useful in this application, having excellent potency as oiliness or film strengthening additives for lubricating oils.[8]

Other Applications. The properties of the higher oxo alcohols suggest use as solvents for fats, oils, waxes, gums and resins. The alcohols and esters of the alcohols may be used as lacquer solvents and as perfumes and industrial odorants. The higher oxo alcohols can be converted to various oxyphosphorus compounds or their sulfur analogs for use as chemical intermediates, antioxidants, anticorrosion agents and hydraulic fluids. Alkaline condensation using a Guerbet-type reaction gives the dimer alcohol which may find use in the production of both anionic and nonionic detergents.

THE FUTURE

These and many other applications explain the rapid expansion in the production of the higher oxo alcohols. The process is quite flexible and is a potential economical source of many other oxygenated chemicals. With the tremendous quantity and wide variety of feed stocks available in the petroleum industry, it is axiomatic that many new oxo derivatives can be expected in the future. At the present time, five companies are producing oxo products in this country.

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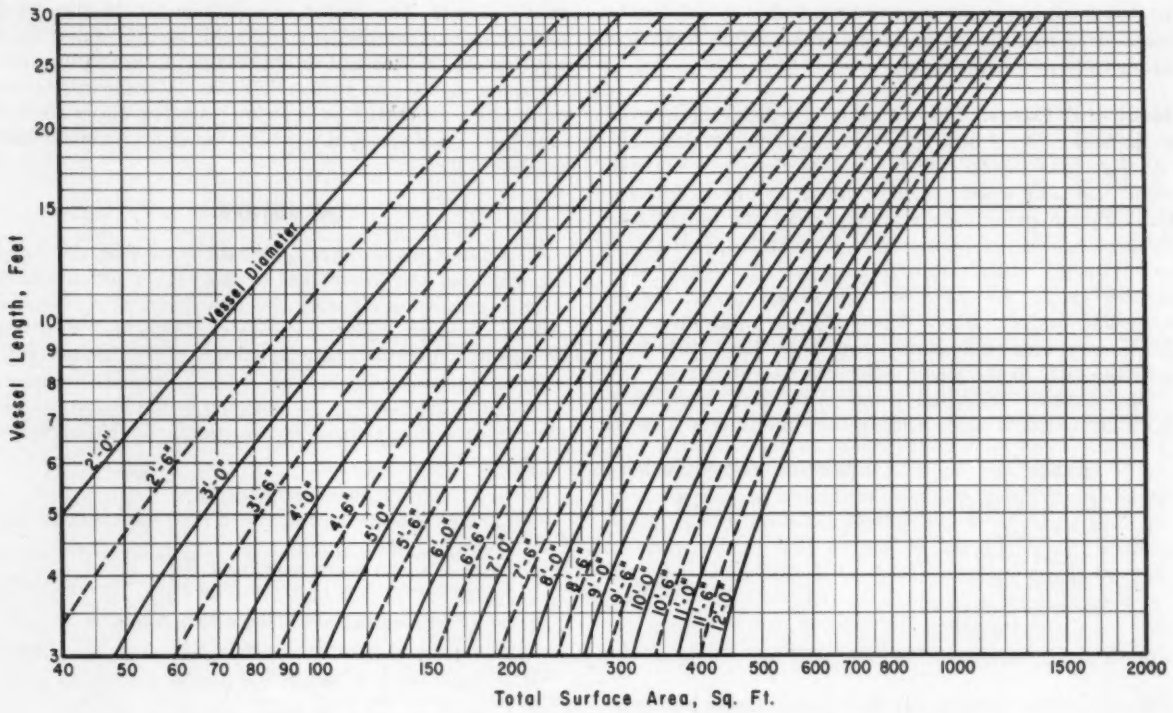

FIGURE 1—This chart applies to towers and drums having 2:1 elliptical heads.

Estimate Tower and Drum Surfaces

This handy chart will help you estimate quickly the total surface areas of towers and drums.

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Foster Wheeler Corporation
New York

THE ENGINEER is frequently faced with the problem of calculating the total surface area of a tower or drum for estimation of insulation requirements, for estimation of surface exposed to fire in safety valve calculation, and for other purposes. The usual procedure is to calculate the area of the heads and add the area of the cylindrical section of the vessel. Charts may be used to eliminate this calculation.

The specified diameter of a vessel is generally the inside diameter whereas the surface area corresponds to outside diameter. When the specified (inside) diameter is employed with Figure 1, the corresponding area will be lower than the true value. For a more accurate value, use the outside diameter.

The formulas for calculating surface area are as follows:

Area of heads $= 2 \times 1.09D^2$
where D = diameter of head

(The formula for head area applies only to standard elliptical heads whose depth is equal to one-fourth the diameter.)

Area of cylindrical section $= \pi DL$
where D = diameter and L = length of the vessel

Total area $= 2.18D^2 + \pi DL$

Use of Figure 1 allows the engineer to avoid tedious calculations and estimate his surface area quickly as illustrated in this example:

Required: Surface area of a drum 5′-0″ diameter x 15′-0″ long.

Solution: Enter Fig. 1 at the ordinate with a vessel length value of 15 ft. and proceed horizontally to the point of intersection with the 5′-0″ diameter parameter. Read the total surface area of 290 square feet at the abcissa.

Correcting for 2-inch thickness: Proceed as before except interpolate to a drum diameter of 5′-4″. Read the total surface area of 310 square feet. ##

Calculate Fluidization Rates

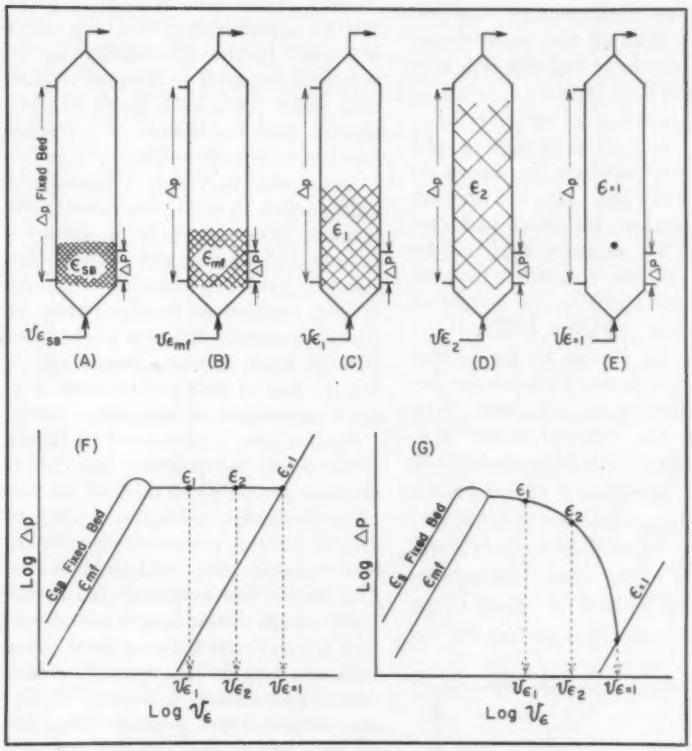

FIGURE 1—Graphical representation of fluidization.

This review of the effects of variables leading to particulate and aggregative fluidization presents a chart for computing fluidization rates and the velocity-bed density relationship for the particulate mode.

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Roslynn Harbor
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THE TERM "fluidization" as applied today in process technology is broadly descriptive of the physical characteristics of a bed of particles under the agitating influence of an upward flowing stream of fluid. A review of the effects of variables which lead to the so-called "particulate" and "aggregative" fluidization characteristics is presented. A generalized chart for computing incipient fluidization rates and the velocity-bed density relationship for the particulate mode is presented. There is also suggested a mechanism of fluidization which might enable at least qualitatively a more realistic description of the forces within the bed. The practical value of such studies lies in the development of means for reducing the contact inefficiencies inherent in aggregative fluidization.

Particulate Fluidization Curve. When gas is passed upward at low velocity through a bed of particles it encounters frictional resistance and exhibits a drop in pressure as it flows through the interstices. This pressure drop, expressed per unit length or depth of bed, has been correlated for all combinations of fluids, solids, and packed bed densities by a number of investigators using various modifications of the earlier work of Chilton and Colburn.[1]

If the bed of particles rests on a grid and is held in place by a fine mesh screen at the bed surface, then the Chilton-Colburn type of correlation applies for any rate of fluid throughput. However, if the bed of particles is not restricted at the surface, then at a sufficiently high fluid velocity, (at which the pressure drop or resistance to flow is equal to or greater than the weight of the bed resting on the grid) the bed will be lifted. Since the particles are not bonded together and merely rest one upon the other, they will move further

Part 5 is a review of the effects of variables leading to fluidization. A method for computing incipient fluidization rates and velocity-bed densities is presented. Part 4—"Nine Variables in Catalyst Flow," which appeared in the July Refiner, discussed the attendant phenomena of catalyst flow through elbows, inclined pipes and feed devices. The effects of moisture content, pipe shape and roughness and erosion were also discussed.

apart and open up the interstices to allow ease of passage of the fluid; thus the bulk density decreases and the bed expands in volume.

The pressure drop-velocity curves for fluid beds are usually depicted as shown in Figure 1 (F), in which the pressure drop across the entire bed is plotted versus velocity. The fixed-bed line represents the typical curve computed from the Chilton-Colburn correlations. As the gas velocity is increased to the point at which the bed is lifted, the particles may rearrange themselves in as loose as possible, but yet fixed-bed configuration. The voidage in this loosest possible configuration is designated as ε_{mf}.

This voidage is best determined experimentally by fluidizing a bed of particles and then slowly decreasing the fluid velocity to zero. The bed height at this point, in conjunction with an experimental voidage determined for the same charge at this or some other bed height (for example by water displacement), gives the value of ε_{mf}.

As an indication of the possible range of values between ε_{SB} and ε_{mf} a density range of at least 29 to 37.5 pounds per cubic foot can be obtained with conventional fluid cracking catalyst corresponding to voidages of 0.74 and 0.66 respectively.

The effect of this range of fixed bed voidages is illustrated diagrammatically in the comparison of Figures 1, (A), (B) and (F) where ε_{SB} is the lower voidage representative of a more densely packed or settled bed. At velocities (through the loosest possible fixed-bed configuration) great enough to give a pressure drop equal to the weight of material in the bed per unit area of tube cross section, the bed expands so that all the particles are no longer touching and the bed is in the so-called fluid state.

Further increase in velocity is accompanied by further increase in bed expansion, or voidage, as shown in Figures 1, (C) and (D); the pressure drop, Δp across the entire bed (recorded by the pressure taps on the left sides of the columns) in both cases remains equal to the weight of bed, as shown in Figure 1 (F).

The line in Figure 1 (F) labeled $\varepsilon = 1.0$ is the pressure drop curve for the fluid flowing in the empty tube as may be calculated from the Fanning equation. The horizontal fluidization line in Figure 1 (F) intersects the $\varepsilon = 1.0$ curve at the velocity, $v_{\varepsilon=1}$ required to balance or support a single particle in the tube. This balancing velocity usually is taken to be equal to the terminal or free-fall velocity as computed from the drag coefficient[5] correlation.

It is assumed that in calculations for any particular case, due corrections will be applied to the standard drag coefficient correlations. By due corrections is meant taking into account the wall effect, as cited by Ladenburg[4]; the relative tube and particle Reynolds number, to account for the controlling flow pattern (the difference between actual balancing velocity and terminal or free-fall velocity can be appreciable); and the effect of vessel height (the difference in velocities required to support or balance single particles 2, 5, 10, 20, etc., feet up from the bottom of a vertical tube vary considerably).

In a tube in which a continuous fluid-particle flow is maintained, the pressure drop generally is discussed in terms of unit length of tube. Because a fluid bed constitutes a form of such continuous flowing system, in which, however, there is only a net flow of fluid, it seems reasonable to make a plot of fluid bed pressure drop on a unit-length-of-bed basis.

Such a plot is illustrated in Figure 1 (G) where the pressure drop, across the taps on the right sides of the columns depicted in Figures 1 (A) to (E), is plotted versus velocity. As the bed expands, the voidage increases and there is less weight of charge material within a unit length of the bed, thus giving lower pressure drop across such unit length. This typical fluidization curve, shown in Figure 1 (G), also intersects the pressure drop line for the empty pipe at the terminal velocity of the individual particles.

Correlating the Particulate Fluidization Curve. In attempting to compute the fluidization curve for a given fluid-solid system, there are two particular points of reference which can be established. The first of these is the bed voidage at its lowest possible fixed-bed configuration, ε_{mf}. If this is not explicitly known, then it must be approximated from curves such as shown in Figure 2 which are based on the data presented by Leva.[7]

The second point to be established is the terminal or free fall velocity of the largest significant particle in the bed of solids. To illustrate what is meant by "significant" suppose for example that the bed is made up of a natural grind having particles ranging from 5 to 150 microns in diameter. At superficial velocities in excess

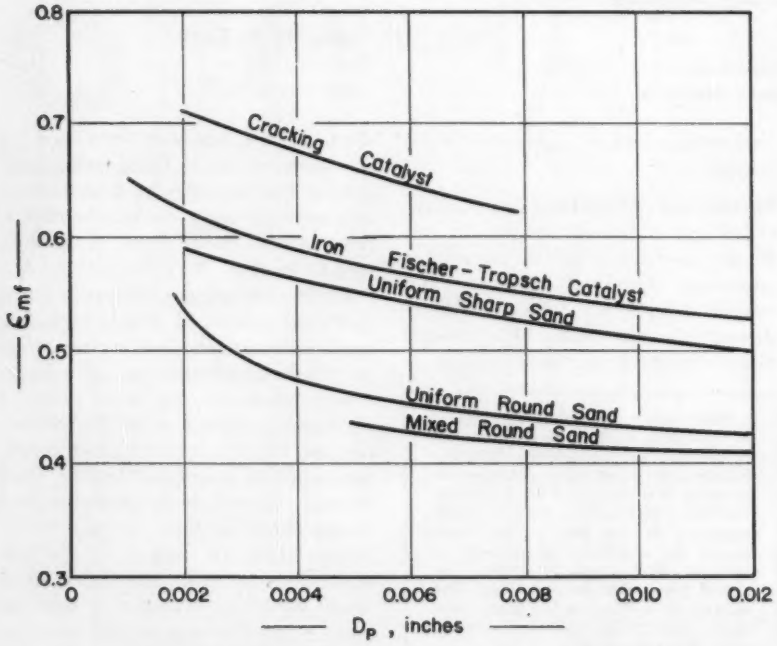

FIGURE 2—Minimum fluid voidage for various materials.

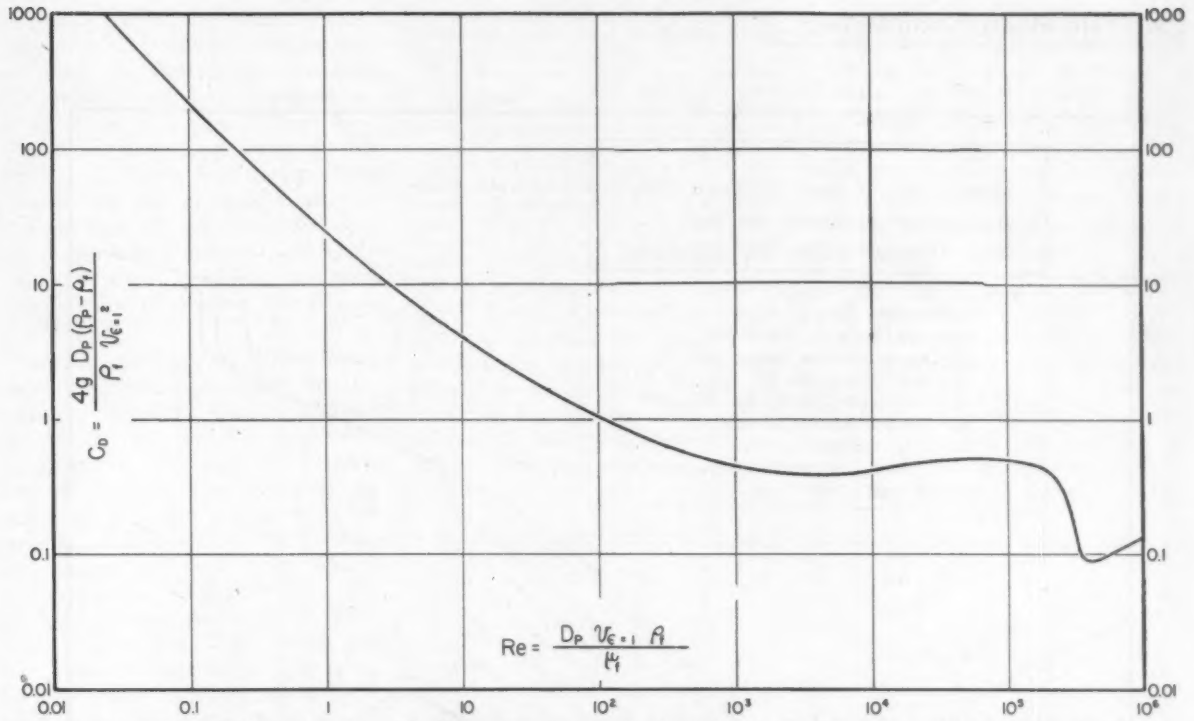

FIGURE 3—Free fall drag coefficient for spheres. The drag coefficient is correlated as a function of the Reynolds number in the convenitonal manner.

of the terminal velocity of the 150 micron particles the bed will rapidly be lost by carryover. If a few ¼-inch diameter particles of the same density are added, the bed will still be rapidly lost at velocities in excess of the terminal velocity of the 150 micron particles. The ¼-inch particles are therefore not "significant" in this instance. Free fall or terminal velocities can be computed from the standard drag coefficient correlation aptly reviewed by Lapple and Shepherd.[5]

To fully describe the fluidization curve between ε_{mf} and $\varepsilon = 1.0$ (where $\varepsilon = 1$ represents an upper fluid velocity limit corresponding to the terminal velocity of the largest significant particle in the bed) a generalized correlation is required for the velocity-voidage relationship. This relationship can be expressed as a modified drag coefficient pertaining to a multiplicity of particles and plotted in the same manner as the standard single particle free fall coefficient.

The drag force on an isolated solid sphere moving in an infinite expanse of stagnant fluid is conventionally represented by the equation:

$$F = \frac{1}{2} C_D \rho_f A v^2_{\varepsilon=1} = \frac{\pi}{8} C_D \rho_f D_P^2 v^2_{\varepsilon=1}$$

The drag coefficient C_D is defined by this equation; it is a function of Reynolds number. For the case of spheres falling through an expanse of stagnant fluid the drag force equals the force of gravity and so

$$F = \frac{\pi}{8} C_D \rho_f D^2_p v^2_{\varepsilon=1} = v_{\varepsilon=1} (\rho_p - \rho_f) g = \frac{\pi}{6} D_p^3 (\rho_p - \rho_f) g$$

Thus, the drag coefficient may be expressed as:

$$C_D = \frac{4}{3} \frac{g D_p (\rho_p - \rho_f)}{\rho_f v^2_{\varepsilon=1}}$$

and correlated as a function of Reynolds number in the conventional manner shown in Figure 3. At Reynolds numbers less than 2.0, C_D is equal to 24/Re which, when substituted in the above definition of C_D and solved for $v_{\varepsilon=1}$, yields the Stokes law relationship:

$$v_{\varepsilon=1} = \frac{g D_p^2 (\rho_p - \rho_f)}{18 \mu_f}$$

In order to calculate terminal velocities at Reynolds numbers beyond the Stokes law range by means of Figure 3, a rather cumbersome trial and error procedure is required since D_P and $v_{\varepsilon=1}$ appear in both abscissa and ordinate. As suggested by Klinkenberg and Mooy[3] this can be averted by plotting $C_D Re^2$ versus Re/C_D where:

$$C_D R_e^2 = D_p^3 \Big/ \left(\frac{3}{4} \frac{\mu_f^2}{\rho_f (\rho_p - \rho_f) g}\right)$$

$$Re/C_D = v_{\varepsilon=1} \Big/ \left(\frac{4}{3} \frac{\mu_f (\rho_p - \rho_f) g}{\rho_f^2}\right)$$

A slight further simplification can be made by plotting $(C_D Re^2)^{1/3}$ versus $(Re/C_D)^{1/3}$ so that in effect this becomes a plot of $v_{\varepsilon=1}$ versus D_p with the bracketed denominators of abscissa and ordinate as constants based on the physical properties of fluid and particles. Such a plot is shown in Figure 4 in which the solid curve labelled $\varepsilon = 1$ represents the standard drag coefficient for spheres.

Smoothed curves drawn through the ranges of experimental data of a number of investigators who have worked with suspensions of higher particle concentration are also shown in Figure 4. Note that the data are all in fairly good agreement so that a reasonable family of curves could be drawn for constant values of particle concentration or bed voidage, ε. Such a plot could then be used in conjunction with Figure 2 to give:

1. The incipient fluidization point,
2. The velocity which will carry the largest particle out of the containing vessel, and
3. The bed density-velocity curve between these limits.

All the available published fluidiza-

Calculate Fluidization Rates . . .

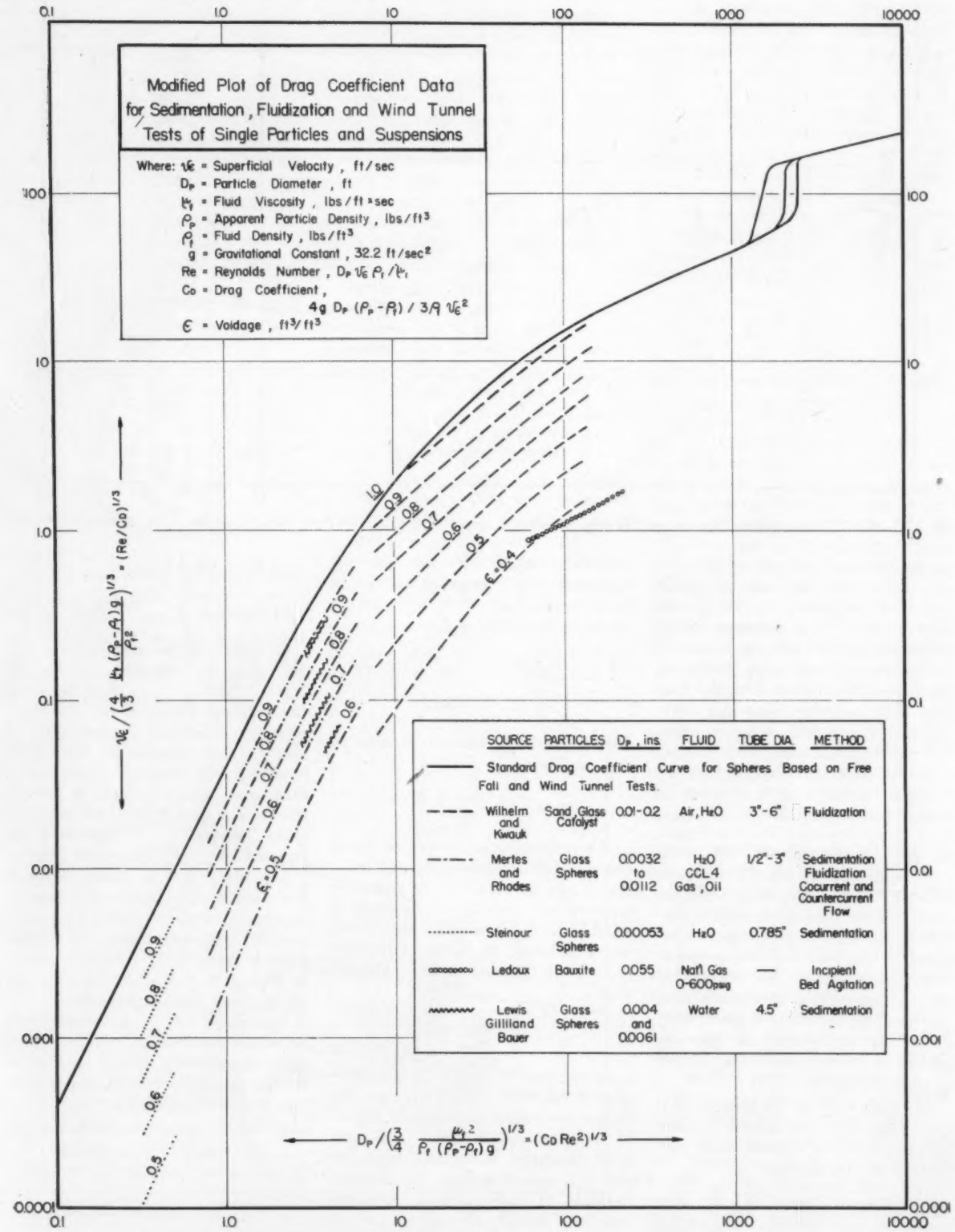
Modified Plot of Drag Coefficient Data for Sedimentation, Fluidization and Wind Tunnel Tests of Single Particles and Suspensions
Where: v_ϵ = Superficial Velocity, ft/sec
D_p = Particle Diameter, ft
μ_f = Fluid Viscosity, lbs/ft×sec
ρ_p = Apparent Particle Density, lbs/ft³
ρ_f = Fluid Density, lbs/ft³
g = Gravitational Constant, 32.2 ft/sec²
Re = Reynolds Number, $D_p v_\epsilon \rho_f / \mu_f$
Co = Drag Coefficient, $4g D_p (\rho_p - \rho_f) / 3\rho v_\epsilon^2$
ϵ = Voidage, ft³/ft³
$v_\epsilon / \left(\frac{4}{3} \frac{\mu_f (\rho_p - \rho_f) g}{\rho_f^2}\right)^{1/3} = (Re/Co)^{1/3}$
$D_p / \left(\frac{3}{4} \frac{\mu_f^2}{\rho_f (\rho_p - \rho_f) g}\right)^{1/3} = (Co\,Re^2)^{1/3}$
SOURCE | PARTICLES | D_p, ins. | FLUID | TUBE DIA. | METHOD
Standard Drag Coefficient Curve for Spheres Based on Free Fall and Wind Tunnel Tests.
Wilhelm and Kwauk | Sand, Glass Catalyst | 0.01-0.2 | Air, H₂O | 3"-6" | Fluidization
Mertes and Rhodes | Glass Spheres | 0.0032 to 0.0112 | H₂O CCL4 Gas, Oil | 1/2"-3" | Sedimentation Fluidization Cocurrent and Countercurrent Flow
Steinour | Glass Spheres | 0.00053 | H₂O | 0.785" | Sedimentation
Ledoux | Bauxite | 0.055 | Natl Gas 0-600psig | — | Incipient Bed Agitation
Lewis Gilliland Bauer | Glass Spheres | 0.004 and 0.0061 | Water | 4.5" | Sedimentation
0.1
1.0
10
100
1000
10000
0.0001
0.001
0.01
0.1
1.0
10
100
ε=0.4
ε=0.5

FIGURE 4—Modified plot of drag coefficient data for sedimentation. Fluidization and wind tunnel tests of single particles and suspensions.

tion data are not shown in Figure 4; only those data which cover the widest range of experimental variables and exhibit uniform bed expansion, as described in Figure 1, have been plotted. Therefore, a limitation on the use of Figure 4 is that, particularly in the case of beds of uniform size particles, any calculated bed density-velocity relationship would apply only to systems exhibiting so-called "particulate" fluidization characteristics.

In the extension to concentrated suspensions the data appear to adequately confirm the equality between the settling velocity of a suspension in quiescent fluid and the counter flowing fluid velocity necessary to maintain the same concentration in continual suspension. In other words, the analogy between sedimentation and fluidization is valid for fluid-solid systems exhibiting particulate fluidization characteristics. (The criteria for this mode of fluidization appear to be the particle size and the ratio of particle to fluid density as discussed in Part III of this series. Quantitative data are given in Figure 11 of Part III.)

Since the abscissa and ordinate of Figure 4 contain only Re and C_D, any point on the grid is defined by the relations

$$A = C_D Re^2 = C_1^2$$

$$B = Re/C_D = C_2^2$$

where *A* and *B* represent the numerical values of ordinate and abscissa at the point in question. These two equations in two unknowns can be solved for the corresponding values of Re and C_D. A similar solution exists for every point on the grid and if loci are drawn through points of equal Reynolds number or drag coefficient this superimposes another grid on the coordinates as shown in Figure 5. The solid curves of Figure 5 represent smoothed curves drawn through the bed voidage parameters of Figure 4.

The usefulness and versatility of Figure 5 can best be demonstrated by means of a few explicit examples.

Example—Estimate the fluidization curve for 0.02 inch diameter sand particles ($\rho_p = 165$ lbs./cu. ft.) in water ($\rho_f = 62.4$ lbs./cu. ft.; $\mu_f = 1.0$ centipoise). (Figure 11 of Part III in this series indicates that this fluid-solid system lies in the particulate range of fluidization).

From Figure 2 ε_{mf} is taken as 0.40. The terms in the denominators of the abscissa and ordinate of Figure 5 are obtained from Figure 6 as 0.00013 and 0.09 respectively; the dotted guide lines of Figure 6 are drawn for this sample illustration.

The abscissa of Figure 5 is therefore $0.02/12 \times 0.00013 = 12.8$. At ε_{mf} this gives an ordinate of 0.09 or $v_{mf} = 0.09 \times 0.09 = 0.0081$ feet/second. Similarly the terminal or free fall velocity is obtained from Figure 5 at $\varepsilon = 1.0$ as $2.6 \times 0.09 = 0.235$ feet/second. Superficial water velocities so obtained at intermediate values of ε, or bed density, define the entire fluidization curve. At any point along the curve Figure 5 also gives the modified Reynold's number.

If for a sand-water system, such as in the preceding example, we were given an operating fluidization point as 0.061 feet per second superficial water velocity at 49.5 pounds per cubic foot bed density and asked to estimate the bed particle size the calculation procedure would be reversed.

Figure 6 would again give the system constants as 0.00013 feet and 0.09 feet per second respectively. The value of the ordinate in Figure 5 would therefore be $0.061/0.09 = 0.68$. The voidage at the given fluidization point would be $1-(49.5/165) = 0.7$. From Figure 5 the abscissa at this value of voidage corresponding to the ordinate of 0.68 would be 12.8 which gives a particle diameter of $12.8 \times 0.0013 = 0.00166$ feet or 0.02 inches.

Checking back with Figure 11 of Part III in this series indicates that this system would be expected to lie in the particulate range which confirms the calculated particle size. The fluidization velocities corresponding to other bed densities are then obtained from the product of the given fluidi-

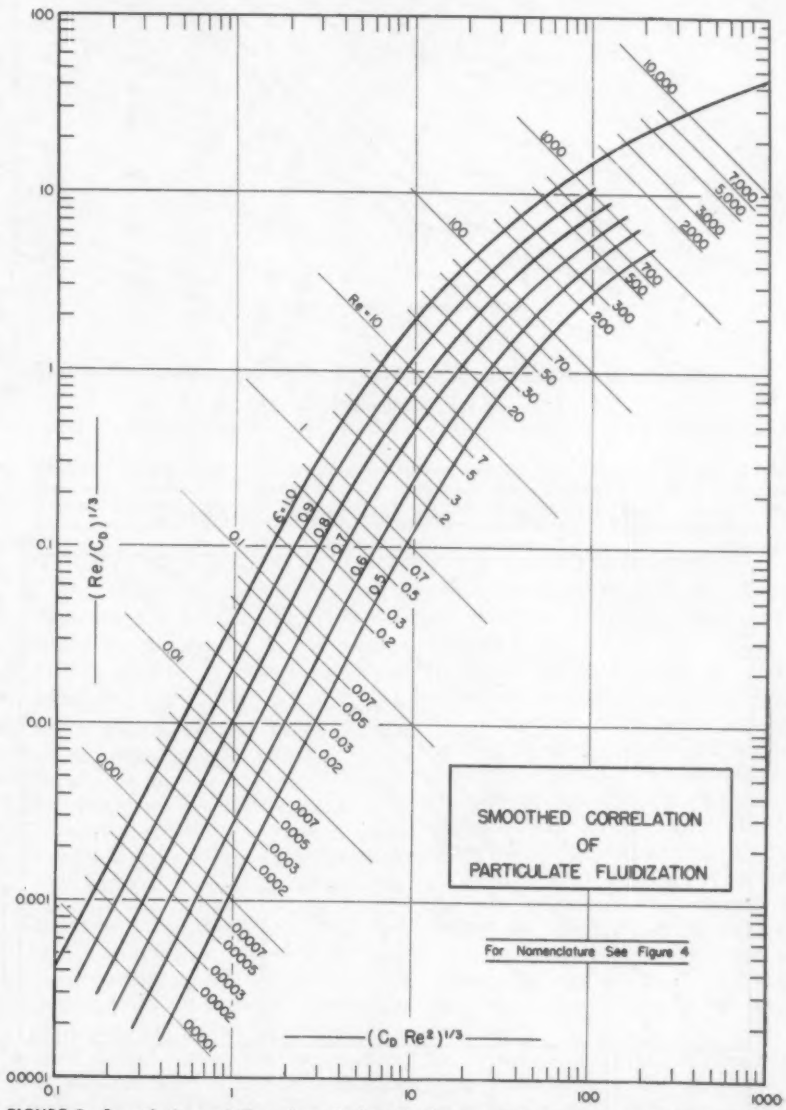

FIGURE 5—Smoothed correlation of particulate fluidization. This curve can be used to estimate the fluidization curve for various sized particles.

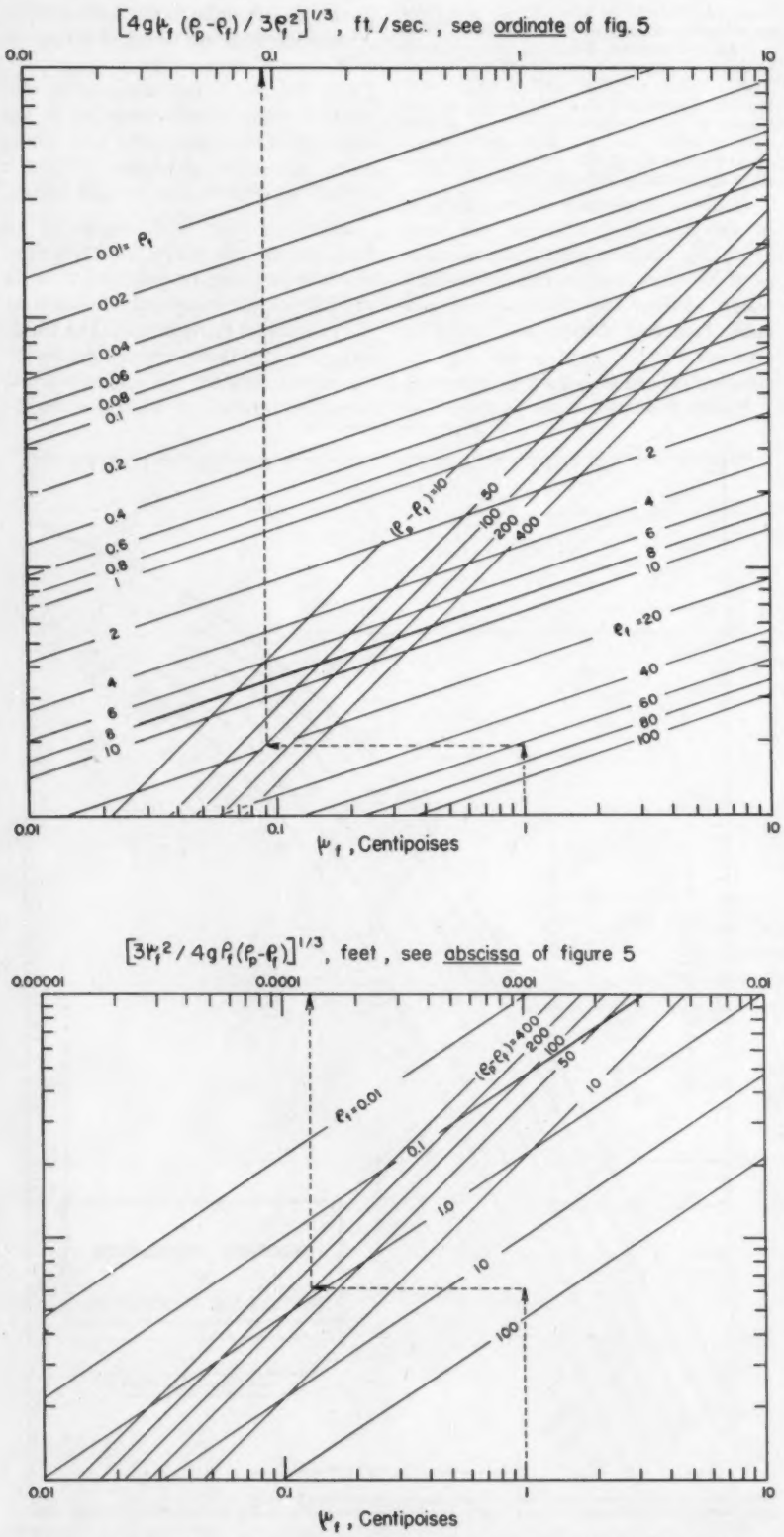

FIGURE 6—Graphical solutions for system constants required in applying the fluidization correlation presented in Figure 5.

zation velocity and the ratio of values of the ordinate at the corresponding voidages.

The system constants obtained from Figure 6 are independent of particle size so that once a density of particle is established, and the fluid known, any choice of particle size, bed density, or superficial velocity can readily be made from Figure 5 for systems in the particulate fluidization range.

This plot also eliminates trial and error in calculating free fall velocities for given particle sizes, or vice versa, at Reynolds numbers beyond the Stokes law range. In this calculation the Reynolds grid is particularly significant as an indication of whether laminar or turbulent flow will govern particle motion.

Particulate and Aggregative Fluidization. The terms "particulate" and "aggregative" fluidization refer to the physical appearance of the fluidized mass. If, upon increasing the superficial fluid velocity through a bed of particles, the bed continually expands, with the spacing between particles increasing uniformly until only a single particle remains in the vessel, as depicted schematically in Figure 1 (A) to 1 (E), then the system is said to exhibit "particulate" fluidization.

If, on the other hand, at velocities above the incipient fluidization rate, the fluid medium passes up through the bed of particles in the form of bubbles, in much the same manner as gases rise through a column of liquid, then the system is said to exhibit "aggregative" fluidization.

The distinction between aggregative and particulate fluidization can easily be demonstrated by comparing the appearance of a bed of 0.02-inch diameter glass beads fluidized with air and with water. The air fluidized bed will exhibit aggregative fluidization whereas with water as the fluid medium the bed will exhibit particulate fluidization.

The data available to date indicate that the range of concentrations in which aggregative fluidization exists is a function of particle size and the ratio of solid to fluid density, and is of the form shown in Figures 10 and 11 of Part III in this series. Commercial gas-phase petroleum cracking processes and laboratory air fluidization expirements fall in the range of ρ_P/ρ_f of approximately 1200, with particle diameters of 60 to 3000 microns. The particulate liquid fluidiza-

tion experiments, on the other hand, have ρ_F/ρ_f values of the order of 2 to 3.

In practice, aggregative fluidization varies widely in degree. Some systems exhibit large bubbles passing upward through the solids, whereas other systems exhibit a greater multiplicity of small diameter bubbles and approach more nearly the particulate flow characteristics. By analogy to the flow of gases through liquids, the degrees of aggregative fluidization have been interpreted in terms of a bed viscosity concept, related to the particle size distribution in the bed, as discussed in Part II of this series.

However, even with the optimization of particle size distribution fluidization with gaseous media is still in practice sufficiently "aggregative" in character to exhibit considerable divergence of the velocity-bed density relation from the curves of Figure 5. This discrepancy was well illustrated by Friend[11] in the discussion of Wilhelm and Kwauk's paper using data taken from commercial plant scale operations. Similar results are obtained with fluid cracking catalysts in laboratory tests.

Typical air fluidization data obtained with a batch of fresh catalyst are shown in Figure 7 in comparison with the smoothed curves of Figure 5 for particulate systems. Note that in addition to anticipated discrepancies at the higher velocities, where aggregative flow characteristics certainly predominate, the incipient fluidization point also falls off the correlation.

In the discussion which follows it will be shown that these discrepancies can apparently be resolved by a proper interpretation of the action within the bed and the effective fluidized particle diameter. This discussion is mainly intended to stimulate interest in the fundamentals of fluidization which may aid in pointing out the direction for future developments in process improvements.

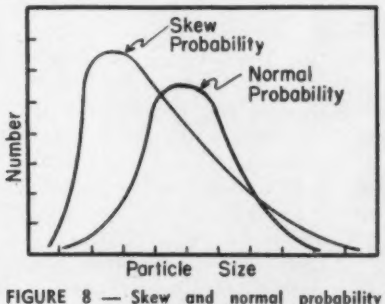

FIGURE 8 — Skew and normal probability distributions.

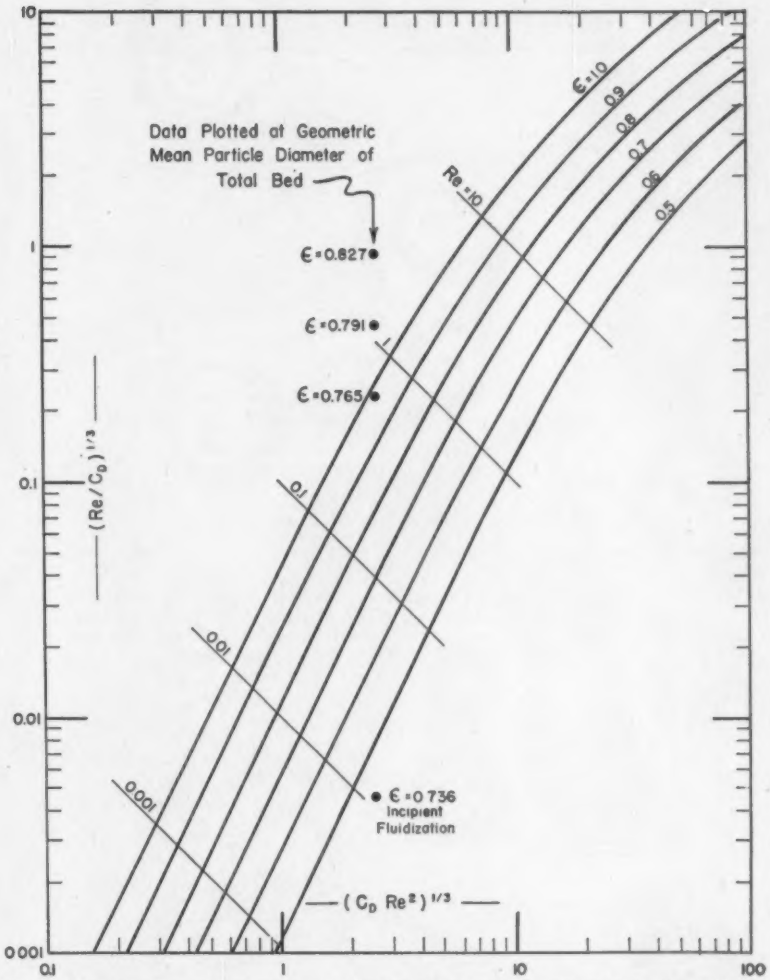

FIGURE 7—Comparison of aggregative fluidization data for FCC catalyst with the particulate fluidization correlation of Figures 4 and 5. Typical air fluidization data obtained with a batch of fresh catalyst. Note that in addition to anticipated discrepancies at the higher velocities where aggregative flow characteristics certainly predominate, the incipient fluidization point also falls off the correlation.

In pratice the simplest means of obtaining the fluidization curve necessary for process design has been to take a sample of the powder and fluidize it with air on a bench scale rather than resort to estimate calculations. Unfortunately such poorly defined data though adequate for process design do not lend themselves to correlation analysis, so that in many instances there exists a sizeable backlog of files of incomplete information.

Particle Size Analyses. The size, and distribution of sizes, of the particles making up the bed are of prime importance to the proper evaluation of fluidization. It has been found that most particles of a sample measured at random obey either of two probability laws. The so-called normal probability or Gaussian distribution and the asymmetrical or "skewed" distribution. These are illustrated in Figure 8.

Hazen[2] in 1914 suggested plotting such size-frequency data in a system of coordinates based on a frequency scale graduated according to the probability integral. On this abscissa scale is plotted the cumulative percent greater than, or less than, the corresponding diameter size given on the ordinate. This method of plotting gives a straight line for normal distributions using an arithmetic scale for the particle diameter and also gives a straight line for "skewed" distributions using a logarithmic diameter scale.

In the macroscopic size ranges the skew-probability is the most general type of particle-distribution occurring in nature. Similarly the size-frequency

Calculate Fluidization Rates . . .

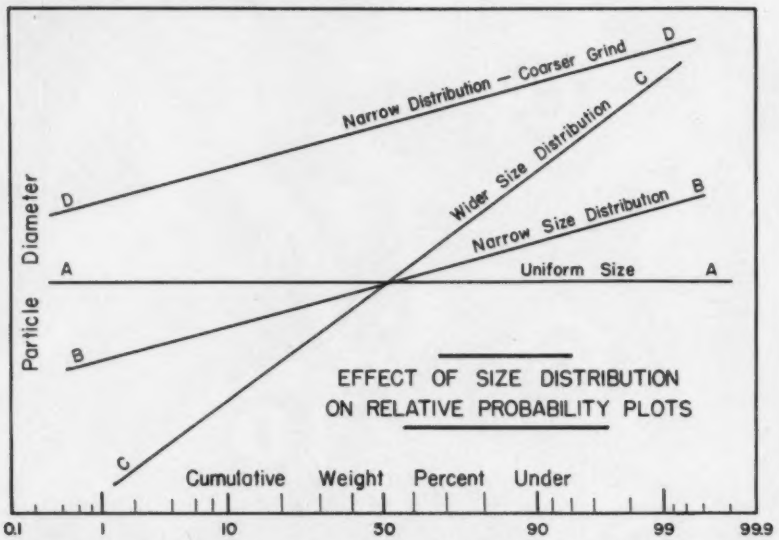

FIGURE 9—Curve B has the same mean particle size with a 10 fold variation in diameter between the largest and smallest particles while C has a 20 fold variation. Curve D has the same 10 fold range of sizes as Curve B but in each weight percent category the particles are larger so that D is a coarser grind than B but equal in range of sizes.

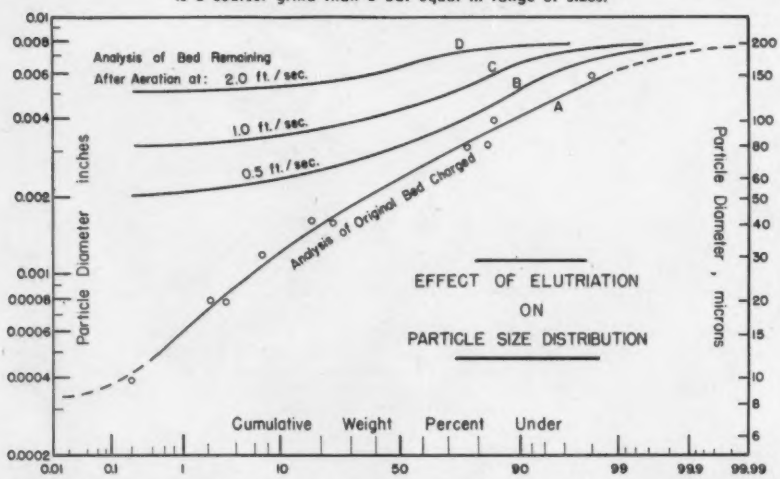

FIGURE 10—Effect of particle size distribution of various aeration rates. Note that rate of entrainment decreases as entrained material is not recycled as shown in Curves B, C and D.

distribution of ground materials also follows more nearly the skew probability. It is common practice therefore, to report particle size analyses on log-probability coordinates since this can be readily extrapolated and interpolated. The 50 percent represents the geometric mean particle size which is usually spoken of as the particle size representative of the mixture. The slope of the line through the data defines the size distribution.

For example, in Figure 9, Curve *A* represents a batch of uniform size particles; Curve *B* has the same mean particle size but has perhaps a 10 fold variation in diameter between the largest and smallest particles while *C* may have a 20 fold variation between the largest and smallest. Curve *D* has the same 10 fold range of sizes as Curve *B*, but in each weight percent category the particles are larger so that *D* is a coarser grind than *B* but equal in range of sizes.

Aggregative Fluidization Data for Mixed Particle Sizes. In practice the fluid cracking "art" has fairly well defined the ranges of particle size distribution optimum to present day methods of plant operation (see Part II in this series). It is therefore common practice to refer to such powders solely in terms of the 50 percent point or geometric mean diameter. However, it is obvious that this is insufficient for quantitative correlation or any fundamental study of the mechanisms occuring in the fluidization process.

As an illustration consider the air fluidization data for a conventional cracking catalyst as presented in Figure 7. The particle size analysis of this material is shown in Curve *A* of Figure 10. Ordinarily this would be simply referred to as a 60 micron particle size catalyst and fluidization data plotted as though it were a batch of uniform size 60 micron particles. Figure 7 illustrates that this does not yield agreement with the particulate fluidization correlation for uniform particles.

The question then arises as to whether this is purely attributable to differences between "aggregative" and "particulate" flow and whether any significant interpretation can be given to the degree of divergence from the particulate correlation. Attempts have been made to interpret the divergence in terms of fluidization efficiency on the premise that the greater the discrepancy the less the material lends itself to efficient fluidization. Otherwise, it has been quite generally accepted that the difference is probably related in some presently indeterminable manner to the aggregative versus particulate mode of flow.

An Approach to Correlation of Aggregative Fluidization. There is still another interpretation which could bear further careful experimental study. Consider the fluidization of the cracking catalyst defined by Figure 10, at a superficial air velocity of 2 feet per second.

Those particles having a terminal or free fall velocity less than 2 feet per second will tend to be carried out of the bed and contribute to the entrainment. The larger particles having terminal velocities greater than two feet per second will tend to remain in the bed. The disengaging height (distance between bed surface and point of gas draw-off) in this instance is ample for the containing vessel diameter and bed depth so that none of the larger particles are carried over with the entrained material, despite the heterogeneous nature of the bubbling flow through the bed.

If the bed were fluidized batchwise without recycling the entrained material the rate of entrainment would

slowly decrease as the bed is depleted of fines and the analysis of the remaining fluidized catalyst would approach Curve *D* of Figure 10. The time during which the fines are being elutriated represents an "unsteady state" period in batch fluidization. Fluidization of the remaining unelutriable particles is then the steady state condition. Obviously the elutriation period is a function of the bed inventory, geometry, grid design, and particle distribution of the initial charge. In a small laboratory apparatus this period would be quite short. It would then certainly seem illogical to plot the velocity-bed density readings at the mean particle size of the initial bed, rather than at the mean particle size of the coarser fluidized bed still in the tube.

In commercial scale operations the so-called entrainment is separated from the exit gases in cyclones and returned to the bed via cyclone diplegs located within the bed or discharging into the reactor feed gas stream. In this instance, the bed may again be considered as a stationary fluidized mass of the coarser particles through which however, the elutriatable "fines" are flowing at a mass velocity equal to the entrainment rate. A sample of "equilibrium" bed catalyst would therefore consist of a mixture of the fluidized particles and the entrainable material flowing through the bed. At 100 percent cyclone efficiency such a sample would give the same analysis as the original fresh feed charge.

In any event, in either batchwise or recycle operation the unelutriatable coarser particles constitute the more characteristic size of the fluid bed. Therefore, in a velocity-density-particle size correlation such as Figure 5, the data for mixed particle size material should not all be plotted at the mean particle size of the fresh charge, but rather at the mean retainable particle size in the bed at the velocity in question.

For example, in Figure 7, fluidization data for 0.5, 1.0, and 2.0 feet per second air rates are plotted at a constant particle diameter of 60 microns, as obtained from Figure 10 for the fresh feed charge.

If, on the other hand, these data were plotted at the mean diameters read from the analyses of the unelutriatable beds, as corespondingly labelled in Figure 10, the data points would be shifted to the right into closer agreement with the curves based on particulate fluidization or aggregative flow through beds of uniform spherical particles. If the data are further corrected for particle shape the points fall into perfect agreement with the curves of Figure 5; this is illustrated in Figure 11.

The particle shape factor, J, may be defined as the ratio of the particle volume to the volume of a sphere having the same effective surface area as the particle. Thus J enters the abscissa as $(C\,Re^2\,J)^{1/3}$ and the ordinate as $(Re/CJ)^{1/3}$.

For cracking catalyst J has a value of approximately 0.52. The justification for this definition of shape factor as well as a survey of the numerous choices described in the literature presents a rather lengthy discourse best left for later treatment.

The agreement obtained in the analysis of the data in Figure 11 is dependent on good particle size distribution data as well as careful fluidization measurements in apparatus not subject to wall effects. This approach to the correlation of aggregative fluidization of mixed particle size material should be explored more exhaustively in a long range experimental program.

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Part 6 will appear in an early issue of the PETROLEUM REFINER.

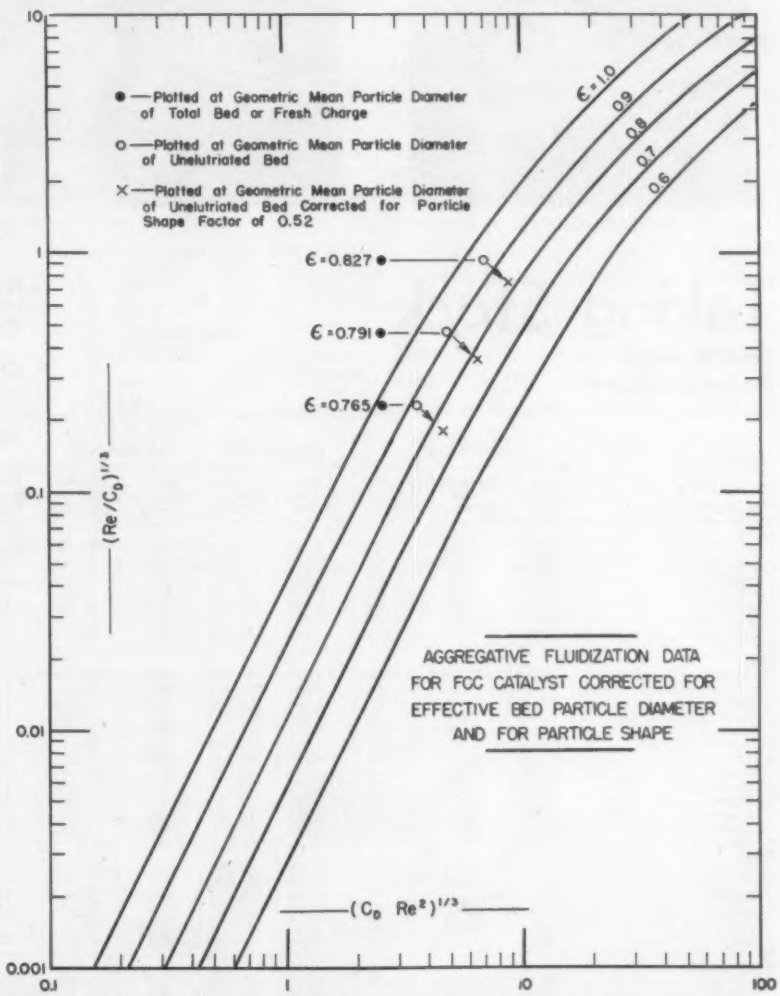
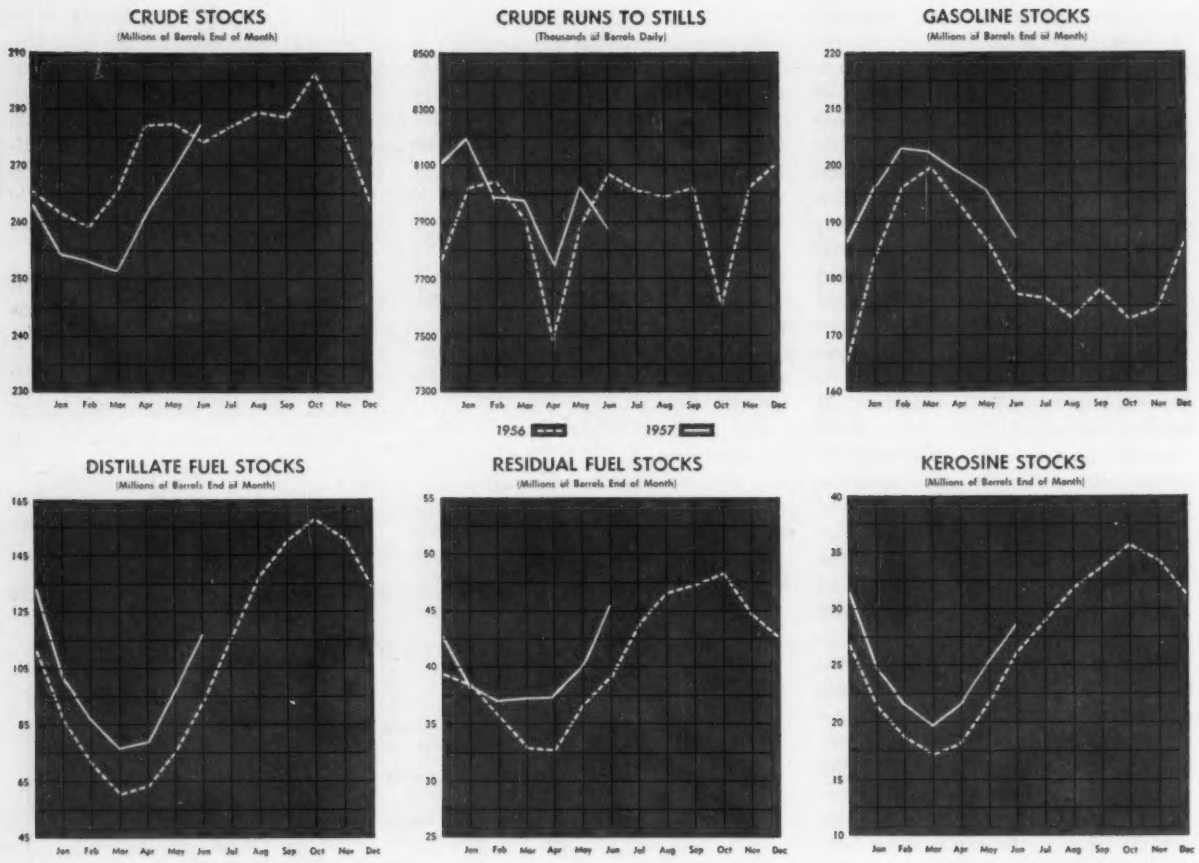


FIGURE 11—These good correlations and agreements are dependent upon good particle size distribution data as well as careful fluidization measurements in apparatus not subject to wall effects.


CRUDE STOCKS
(Millions of Barrels End of Month)
CRUDE RUNS TO STILLS
(Thousands of Barrels Daily)
GASOLINE STOCKS
(Millions of Barrels End of Month)
1956
1957
DISTILLATE FUEL STOCKS
(Millions of Barrels End of Month)
RESIDUAL FUEL STOCKS
(Millions of Barrels End of Month)
KEROSINE STOCKS
(Millions of Barrels End of Month)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Taking Stock

Cecil W. Smith
Economics Editor

Refinery runs below last year's
Gasoline stocks nearing 1956's
Oil imports hit all-time high

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1955:													
June	6,613	7,484	270,850	3,725	157,439	269	29,830	1,628	100,652	1,080	44,398	764	1,159
July	6,632	7,580	264,601	3,824	157,079	286	32,749	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	290	35,292	1,621	133,675	1,090	45,480	756	1,155
September	6,731	7,483	256,269	3,784	150,194	279	36,361	1,621	143,248	1,061	46,267	829	1,218
October	6,837	7,465	267,346	3,827	153,103	309	36,705	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	341	35,283	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	395	26,770	1,765	111,333	1,286	39,174	884	1,502
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	385	18,712	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	342	17,215	1,808	60,846	1,213	32,984	934	1,425
April	7,146	7,487	277,121	3,646	193,299	299	18,227	1,713	63,571	1,130	32,740	815	1,305
May	7,064	7,896	277,497	3,859	186,673	292	21,883	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	290	26,111	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	296	28,990	1,767	115,787	1,066	43,958	1,084	1,463
August	7,195	7,995	279,944	4,037	172,939	313	31,826	1,839	137,905	1,091	46,617	1,001	1,399
September	7,054	8,024	278,791	3,991	177,974	329	33,588	1,845	150,411	1,062	47,342	1,043	1,452
October	6,966	7,608	286,560	3,773	172,798	356	35,667	1,772	158,871	1,082	48,400	1,004	1,541
November	7,139	8,031	275,995	3,913	174,808	384	34,329	1,841	151,517	1,182	44,590	871	1,362
December	7,377	8,141	266,014	4,039	187,271	379	31,420	1,981	133,981	1,288	44,491	873	1,471
1957:													
January	7,480	8,274	256,669	3,991	197,702	367	24,019	2,118	100,572	1,322	38,403	805	1,425
February	7,682	8,088	256,344	3,864	205,270	353	21,013	2,035	85,105	1,270	31,201	780	1,430
March	7,717	8,047	254,911	3,826	206,716	332	20,223	1,861	76,245	1,205	37,371	836	1,464
April	7,541	7,740	265,796	3,770	201,407	284	21,512	1,764	78,743	1,132	37,429	906	1,542
May	7,457	8,029	269,124	3,843	195,039	285	25,198	1,829	97,700	1,136	40,235	1,028	1,443
June	7,231	7,876	277,532	3,898	187,407	262	28,377	1,743	116,966	1,129	45,342	1,173	1,605
Week Ended:													
7-12-57	6,882	7,972	280,458	3,837	181,973	250	29,253	1,857	125,564	1,106	47,020	1,287	1,642
7-13-56	7,084	8,028	275,132	3,885	178,366	324	27,415	1,801	104,521	1,128	40,926	1,066	1,446

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

Need Help With Gas Chromatography?

If you are using or considering chromatographic methods, you may want to try the columns and partition liquids suggested in this informative report.

H. N. Morrow and K. B. Buckley
Delhi-Taylor Oil Corporation
Corpus Christi, Texas

GAS CHROMATOGRAPHY has become an extremely important tool to our company's refining operations. Due to its speed, simplicity, reliability and low operating cost, this method of analysis is generally preferred whenever possible. Efforts have concentrated on finding adequate partition columns to do the jobs required, and many of the present columns will be replaced when there has been time to test some of the 20 or more potential partition liquids on hand. Many of these liquids are listed in the literature.[1,2]

The information given here will be of a general nature and can be applied to most makes of instruments. The instrument, and related equipment, includes an attenuator and devices which enable the operator accurately to measure and duplicate the size of liquid or gas samples. The support for the partition liquid on all of the columns is celite, 50-60 or 60-80 mesh, that has been wet screened, acid washed and then dry screened. All partition packings use a ratio of 4 parts partition liquid to 10 parts celite by weight.

Separation of Saturated Hydrocarbons. A column of vacuum pump oil (VPO) is used for the separation of saturated hydrocarbons, this partition being preferred to the phthalates and silicone oil No. 200. For the saturated hydrocarbons through normal pentane, a 12-foot column is used at 40 C. (Table 1 and Figure 1). It should be mentioned that oxygen, nitrogen, hydrogen and carbon dioxide will be eluted with methane, if present. This column is being used for crude unit off-gases, stabilizer off-gases, field LPG, natural gas and light fractions from crude analysis.

This column is also used for liquid samples, such as straight-run gasoline or platformates, to determine the lower boiling components. In this case, after the lighter components are separated, the column is stripped of the heavier components at 100 C.

Using this column at 75 C. separate the paraffin and naphthene hydrocarbons boiling at, or below, the boiling point of methylcyclopentane with the exception of diisopropyl, 2-methylpentane, and cyclopentane.

TABLE 1
Separation of Saturated Hydrocarbons Through Pentane on Vacuum Pump Oil Column. (See Figure 1)

Sample:	Crude unit separator off-gas plus isopentane and n-pentane
Sample Size:	2 ml — gas @ 40° C
Column Packing:	Welsh vacuum pump oil on 60-80 mesh celite
Column Size:	Copper 12′ x ¼″ I.D.
Column Temp.:	40° C (Glas-Col Jacket)
Eluent Gas:	Helium @ 50 ml/min inlet. 86.0 ml/min outlet
Back Pressure:	12.5 lb gage
Cell Temp.:	40° C
Cell Current:	120 ma

RETENTION TIMES

Peak No.	COMPONENT	Retention Time (Minutes)
1	Methane (O_2, N_2, H_2 or CO_2 if present)	3.0
2	Ethane	3.6
3	Propane	5.0
4	Isobutane	7.4
5	n-Butane	9.8
6	Isopentane	18.4
7	n-Pentane	23.5
8	Neopentane (if present)	11.4

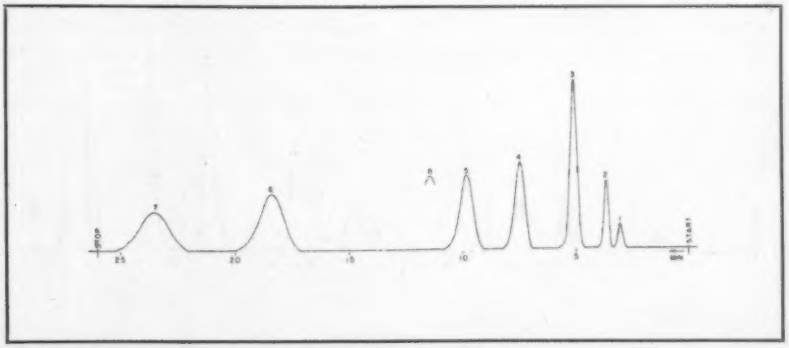


FIGURE 1—VPO Column.

TABLE 2

Separation of Saturated Hydrocarbons Up to Methylcyclopentane on Vacuum Pump Oil Column. (See Figure 2)

Sample:	Fraction from Renwar crude oil
Sample Size:	0.01 ml — liquid @ 0° C
Column Packing:	Welsh vacuum pump oil on 60-80 mesh celite
Column Size:	Copper 12′ x ¼″ I.D.
Column Temp.:	75° C (hot water bath)
Eluent Gas:	Helium @ 50 ml/min inlet. 91 ml/min outlet.
Back Pressure:	14.5 lb. gage
Cell Temp.:	100° C
Cell Current:	120 ma

RETENTION TIMES

Peak No.	COMPONENT	Retention Time (Minutes)
1	Isobutane	4.3
2	n-Butane	5.3
3	Isopentane	8.4
4	n-Pentane	10.2
5	2,2-Dimethylbutane	13.6
6	2,3-Dimethylbutane 2-Methylpentane Cyclopentane	17.6
7	3-Methylpentane	20.2
8	n-Hexane	22.9
9	Methylcyclopentane	30.8

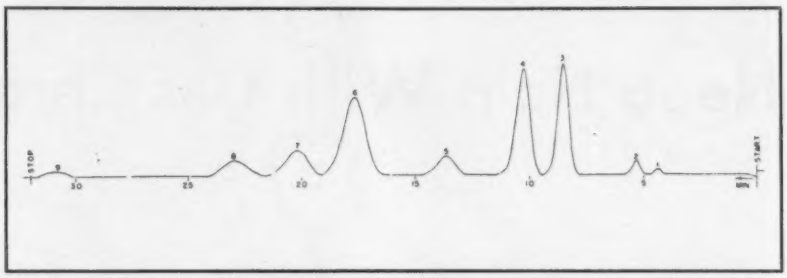


FIGURE 2—VPO Column.

These three are eluted in a single peak (Table 2 and Figure 2). By using a benzyl benzoate column (BB), the relative retention time of the cyclopentane is increased so that it is eluted with the normal hexane (Table 3 and Figure 3). (This column can not be stripped above 100 C. without decomposition.) The operators are still trying to find a partition liquid to separate diisopropyl and 2-methylbutane within a reasonable elution time. The fraction boiling between the butanes and BTX platformer charge stock is evaluated by using these two columns in succession.

TABLE 3

Separation of Saturated Hydrocarbons Up to Methylcyclopentane on Benzyl Benzoate Column. (See Figure 3)

Sample:	Fraction from Renwar crude oil
Sample Size:	0.01 ml — liquid @ 0° C
Column Packing:	Benzyl Benzoate on 50-60 mesh celite
Column Size:	Copper 12′ x ¼″ I.D.
Column Temp.:	75° C (Hot water bath)
Eluent Gas:	Helium @ 50 ml/min inlet. 78 ml/min outlet
Back Pressure:	10.0 lb. gage
Cell Temp.:	100° C
Cell Current:	120 ma

RETENTION TIMES

Peak No.	COMPONENT	Retention Time (Minutes)
1	Isobutane	3.2
2	n-Butane	3.7
3	Isopentane	5.1
4	n-Pentane	6.0
5	2,2-Dimethylbutane	7.2
6	2,3-Dimethylbutane 2-Methylpentane	9.2
7	3-Methylpentane	10.4
8	n-Hexane Cyclopentane	11.8
9	Methylcyclopentane	17.8

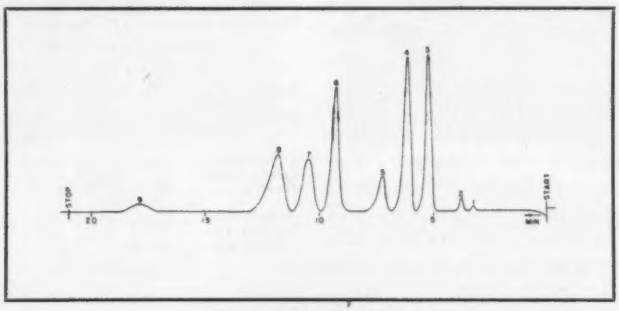


FIGURE 3—B B Column.

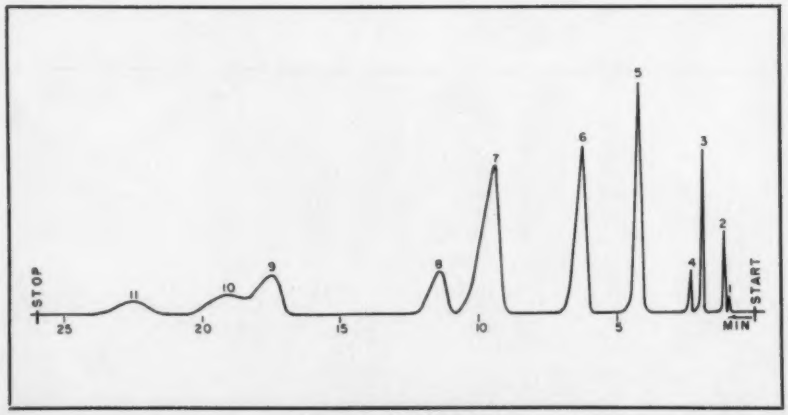


FIGURE 4—MAA Column.

TABLE 4

Separation of Unsaturated Hydrocarbons Below the C_4's on a Modified Activated Alumina Column. (See Figure 4)

Sample:	Poly reactor charge plus carbon dioxide
Sample Size:	3 ml — gas @ 40° C
Column Packing:	48-60 mesh activated alumina modified with 2% silicone oil (No. 200, 50 cs @ 25° C)
Column Size	Glass 2½ Meter x ¼″ I.D.
Column Temp.:	70° C (Spiral wire heating coil)
Eluent Gas:	Helium @ 55 ml/min inlet. 86 ml/min outlet
Back Pressure:	10 lb. gage
Cell Temp.:	100° C
Cell Current:	140 ma

RETENTION TIMES

Peak No.	COMPONENT	Retention Time (Minutes)
1	Carbon Dioxide (O_2, N_2, or H_2 if present)	0.9
2	Methane	1.1
3	Ethane	1.9
4	Ethylene	2.3
5	Propane	4.2
6	Propylene	6.2
7	Isobutane	9.3
8	n-Butane	11.4
9	Butene-1 Isobutylene	17.4
10	trans-Butene-2	19.0
11	cis-Butene-2	22.5

Separation of Unsaturated Hydrocarbon Mixtures. Mixtures of unsaturated hydrocarbons below the C_4's are separated by a modified activated alumina column. This column is 48-60 mesh activated alumina (approximately 0.8 percent Na_2O and 0.2 percent SiO_2) modified with 2 percent by weight of silicone oil (No. 200, 50 cs at 25 C.) (MAA.) This modification reduces the retention time of all components and reduces the "tailing" of the peaks which is characteristic of solid adsorbents. The modification does not change the order of elution of the components. This column will separate methane as a second peak leaving nitrogen, oxygen or hydrogen in the first peak (Table 4 and Figure 4). It will be noted that the C_4 unsaturates (while they are grouped) are not separated. This column is used for deethanizer off-gas and for propane production control. The column is stripped at 150° C.

Butene-1 and isobutylene may be separated on a dimethylformamide column (DMF) at 0 C. It is necessary to saturate the carrier gas by means of a dimethylformamide bubbler ahead of the instrument in order to prevent eventual stripping of the partition liquid from the column (Table 5 and Figure 5). It can be noted that the separation of ethylene is not good and that propylene is eluted with isobutane. Any isopentane present would be eluted with the isobutylene. The addition of a section of column of silicone oil moved the propylene peak to a position between the propane and the isobutane peak; however, the isopentane was still eluted with the unsaturated C_4's, so the combination is not being used. This column has been used only once in the last year for the separation of butene-1 andw isobutylene which is of little interest to our operations.

The separation obtained on a diethylformamide column (DEF) is similar to that on the DMF column, except the isobutylene and butene-1 are eluted in a single peak and the isopentane is eluted with the cisbutene-2. The operators have been using a combination DEF and silicone oil column (DEF/SO). The silicone oil section delays the isopentane and separates the propylene from the isobutane (Table 6 and Figure 6). This column is used at room temperature with a DEF bubbler in the carrier gas stream. This column is used for determining the purity of n-butane, isobutane and mixed C_4's.

More recently there has been developed a new column using vacuum pump oil in conjunction with hexamethylphosphoramide (VPO/HMP). The separation is similar to the DEF/SO column (Table 7 and Figure 7). This column has now replaced the DEF/SO column for analysis of the C_4 mixtures. The higher boiling point

TABLE 5

Separation of Butene-1 and Isobutylene on a Dimethylformamide Column. (See Figure 5)

Sample:	Poly reactor charge
Sample Size:	2 ml — gas @ 40° C
Column Packing:	Dimethylformamide on 60-80 mesh celite
Column Size:	Copper 18′ x ¼″ I.D.
Column Temp.:	0° C (Ice and water bath)
Eluent Gas:	Helium @ 50 ml/min (Saturated with DMF) inlet. 80 ml/min. outlet.
Back Pressure:	10.7 lb. gage
Cell Temp.:	40° C
Cell Current:	140 ma

RETENTION TIMES

Peak No.	COMPONENT	Retention Time (Minutes)
1	Methane (N_2, O_2, or H_2 if present)	2.6
2	Ethane	3.0
3	Ethylene	3.3
4	Propane	4.0
5	Propylene Isobutane—Attenuated	5.4
6	n-Butane	7.1
7	Butene-1	11.0
8	Isobutylene	12.0
9	trans-Butene-2	13.9
10	cis-Butene-2	16.1
11	Neopentane (if present)	7.1
12	Isopentane (if present)	12.4

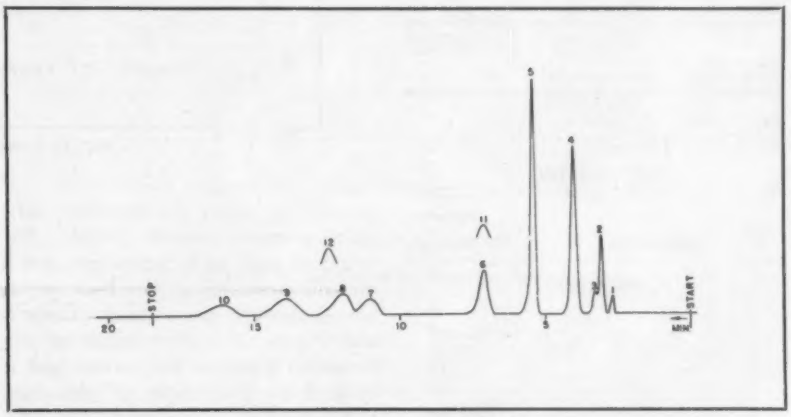


FIGURE 5—DMF Column.

TABLE 6

Separation of Unsaturated Hydrocarbons Below the C_5's With a Combination Diethylformamide and Silicone Oil Column. (See Figure 6)

Sample:	Poly reactor charge
Sample Size:	2 ml-gas @ 40° C
Column Packing:	18′ of diethylformamide on 60-80 mesh celite followed by 5′ 4″ of silicone oil (No. 200, 50 cs @ 25° C) on 60-80 mesh celite
Column Size:	Copper 23′ 4″ x ¼″ I.D.
Column Temp.:	30° C (Water bath)
Eluent Gas:	Helium @ 45 ml/min (Saturated with DEF) inlet 86 ml/min outlet.
Back Pressure:	16 lb. gage
Cell Temp.:	40° C
Cell Current:	120 ma

RETENTION TIME

Peak No.	COMPONENT	Retention Time (Minutes)
1	Methane (H_2, O_2, or N_2 if present)	4.2
2	Ethane Ethylene	4.7
3	Propane	6.1
4	Propylene	6.6
5	Isobutane	8.2
6	n-Butane	10.1
7	Butene-1 Isobutylene	11.4
8	trans-Butene-2	13.0
9	cis-Butene-2	14.6
10	Isopentane	17.3
11	n-Pentane	21.2

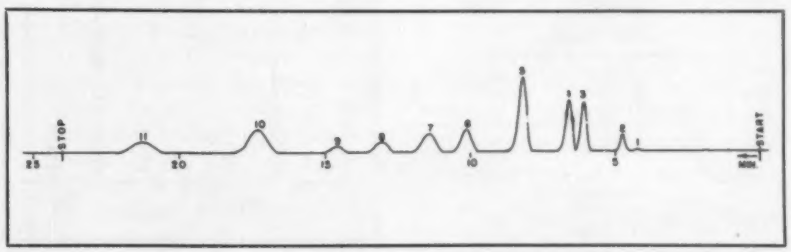


FIGURE 6—DEF/SO Column.

TABLE 7

Separation of Unsaturated Hydrocarbons Below the C_5's With a Combination Vacuum Pump Oil and Hexamethylphosphoramide Column. (See Figure 7)

Sample:	Poly reactor charge plus isopentane and n-pentane
Sample Size:	2 ml — gas @ 40° C
Column Packing:	1' 4" of vacuum pump oil on 60-80 mesh celite followed by 16' of hexamethylphosphoramide on 50-60 mesh celite
Column Size:	Copper 17' 4" x ¼" I.D.
Column Temp.:	Room temperature
Eluent Gas:	Helium @ 45 ml/min inlet. 77 ml/min outlet
Back Pressure:	13.5 lb. gage
Cell Temp.:	40° C
Cell Current:	120 ma

RETENTION TIME

Peak No.	COMPONENT	Retention Time (Minutes)
1	Methane (O_2, N_2, or H_2 if present)	2.9
2	Ethane, Ethylene	3.3
3	Propane	4.5
4	Propylene	5.2
5	Isobutane	6.6
6	n-Butane	8.6
7	Butene-1, Isobutylene	10.3
8	trans-Butene-2	12.1
9	cis-Butene-2	13.6
10	Isopentane	15.9
11	n-Pentane	17.6

(100 C. @ 6mm Hg) of the HMP makes it much more desirable as a partition agent. The separation of the mixed C_5's is being determined by this column. Separation is shown in Table 9.

Quantitative Determination Of Hydrogen. The percentage of hydrogen may be obtained in a few minutes on any gas stream, even if nitrogen is present, by using the modified activated alumina column (MAA). Nitrogen is used as a carrier gas and a measured volume of pure hydrogen is passed through the column (Table 8 and Figure 8). The height of the hydrogen peak in the sample gas is divided by the height of the pure hydrogen peak and multiplied by 100. This is termed "percentage of total height." The percentage of hydrogen is read from a calibration curve plotted from known samples, as shown in Figure 9. Attenuation, a low gas flow, and a reduced cell current are necessary to keep the hydrogen peak on the chart and to keep the pen speed below maximum. The two successive runs assure peak height comparison with duplication of conditions. The error has proven to be less than ½ percent of hydrogen at any hydrogen concentration. The hydrogen content of the recycle gas on our platformer is run regularly by this method.

TABLE 8

Quantitative Determination of Hydrogen. (See Figure 8)

Sample:	Absorber off-gas (gas concentration unit)
Sample Size:	1 ml — gas @ 40° C
Column Packing:	MAA (see Table IV)
Column Size:	Glass 2½ Meter x ¼" I.D.
Column Temp.:	65° C (Spiral wire heating coil)
Eluent Gas:	N_2 @ 32 ml/min inlet. 45 ml/min outlet
Back Pressure:	7.5 lb. gage
Cell Temp.:	100° C
Cell Current:	110 ma

PEAK HEIGHTS
(Attenuated to 5% of Maximum)

Peak No.	COMPONENT	Height
1	Hydrogen—Pure	8.03"
2	Hydrogen from sample	3.50"

CALCULATIONS

$$\text{Percentage of total height} = \frac{3.50}{8.03} \times 100 = 43.6\%$$

Volume percent hydrogen = 30.5% (See Figure 9)

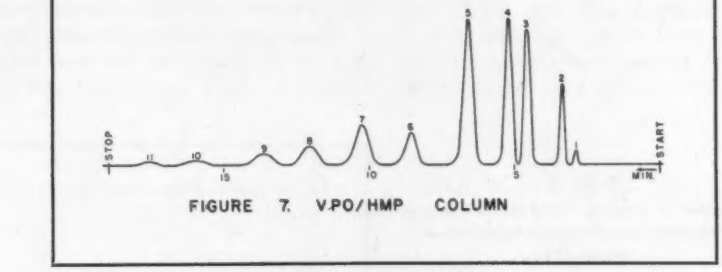


FIGURE 7—VPO/HMP Column.

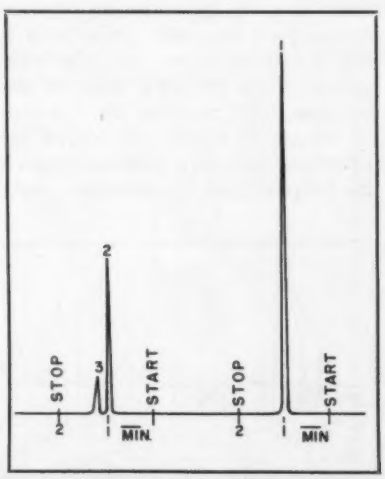


FIGURE 8—MAA Column.

The balance of the components are run on this same MAA column for light samples, such as the absorber off-gas (gas concentration unit), which contains nitrogen and the lighter unsaturated gases. Hydrogen is used as a carrier gas in this case, in order to eliminate the hydrogen peak. Any other column can be used for the components present with the hydrogen.

Calculations For Quantity of Components. For calculating the quantity of components we use peak areas measured with a planimeter. This method is used in order to avoid rigid control of conditions. To standardize, we run either prepared or standard mixtures. An emperical factor is determined for each component so that when the peak area of each component is multiplied by its factor, the areas will be proportional to the mole percent of each component.

When all components of a sample are run, we do not have to hold rigidly to one set of conditions in order to calculate mole percent. We have found that when conditions are changed, the effect on the area of each component peak is the same; that is, the ratio of areas remains the same. The recording pen must operate below maximum travel speed in order for this to hold true.

When all components of a sample are recorded, we first measure each component area with a planimeter to obtain "uncorrected peak areas." Each of these areas are then multiplied by the component's factor to obtain "corrected peak areas." These corrected areas are added to obtain

TABLE 9

Separation of Unsaturated Hydrocarbons in the C_5 Range With a Combination Vacuum Pump Oil and Hexamethylphosphoramide Column.

Sample:	Blend of Phillips unsaturated C_5's plus isopentane and n-pentane.
Sample Size:	0.01 ml liquid at 0° C
Column Packing:	1′ 4″ of vacuum pump oil on 60-80 mesh Celite followed by 16′ of hexamethylphosphoramide on 50-60 mesh Celite.
Column Size:	Copper 17′ 4″ x ¼″ I.D.
Column Temp.:	35° C (Glas-Col jacket)
Eluent Gas:	Helium @ 45 ml/min inlet. 73 ml/min outlet.
Back Pressure:	11.0 lb. gage
Cell Temp.:	40° C
Cell Current:	120 ma

RETENTION TIMES

Peak No.	COMPONENT	Retention Times (Minutes)
1	Isopentane	16.4
2	3-Methylbutene-1	17.9
3	n-Pentane	20.7
4	Pentene-1	24.6
5	2-Methylbutene-1	26.4
6	Pentene-2 (cis and trans)	28.9
7	2-Methylbutene-2	33.0

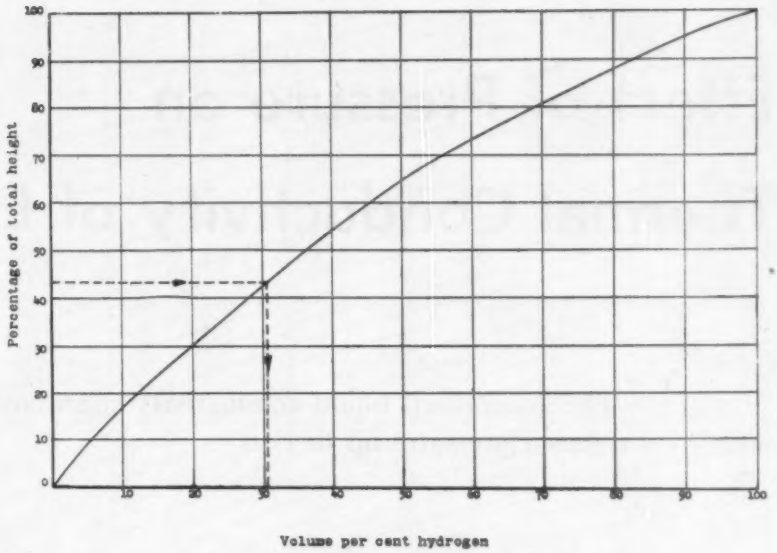


FIGURE 9—Calibration of Hydrogen Peak Heights.

a total "corrected area" for all components. The percent of each component area is then calculated. This is equal to mole percent. The error has proven to be not greater than 0.3 percent for components from methane through methylcyclopentane.

We have a few liquid samples, such as straight run gasoline, and platformate, on which we determine only a few of its lighter components. Standardization of conditions, as well as standardization of sample volume and temperature, is necessary. While we have held column construction, column temperature and cell temperature at the same value that existed during calibration, this may not be necessary. It is necessary, however, to closely control the cell current and eluent gas flow. By running known samples, component factors are determined which will give liquid volume percent when multiplied by the component's peak area. For determination of the saturated hydrocarbons through n-pentane (on VPO column) the error has proven to be not greater than 0.2 percent of the sample or not over 5 percent of the component, which ever is greater.

A recent publication dealing with the relationship of peak areas to mole percent and the effect of varying conditions was published in the January issue of Analytical Chemistry.[3] Percival, in his paper, has confirmed the relationship we have observed between peak areas and quantity of a component. We have determined that the effect of varying conditions is the same on all component areas and that rigid control is not necessary when all component areas can be measured.

ACKNOWLEDGMENT

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(d) Mr. R. H. Featherston, Reynolds Metals Company, for supplying the activated alumina used in the MAA column.

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Morrow

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Effect of Pressure on Thermal Conductivity of Liquids

The generalized liquid conductivity chart covers most liquids with high accuracy for reduced pressures up to 12.0.

J. M. Lenoir
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Alhambra, Calif.

THE THERMAL conductivity of a liquid is important in the design and operation of heat-exchangers. This paper presents a generalized empirical method to account for the effect of pressure. The method correlates the available thermal conductivity data with an average deviation of less than two percent.

The assumption that thermal conductivities of liquids are independent of pressure changes is usually justified for pressure changes of 500 pounds per square inch or less. For larger pressure changes, thermal conductivity significantly increases as pressure increases (Figure 1). It is desirable, for the purpose of high pressure heat transfer computations, to have a method to predict the change in thermal conductivity with pressure.

Qualitatively the change of thermal conductivity with pressure follows in form the density behavior of liquids, as pointed out by Bridgman.[1] The empirical method of Watson[4] satisfactorily correlates the density of liquids. Watson introduced the concept of the expansion-factor, ω, with

$$\frac{\rho_2}{\rho_1} = \frac{\omega_2}{\omega_1} \qquad (1)$$

The rate of change of thermal conductivity with changes in pressure

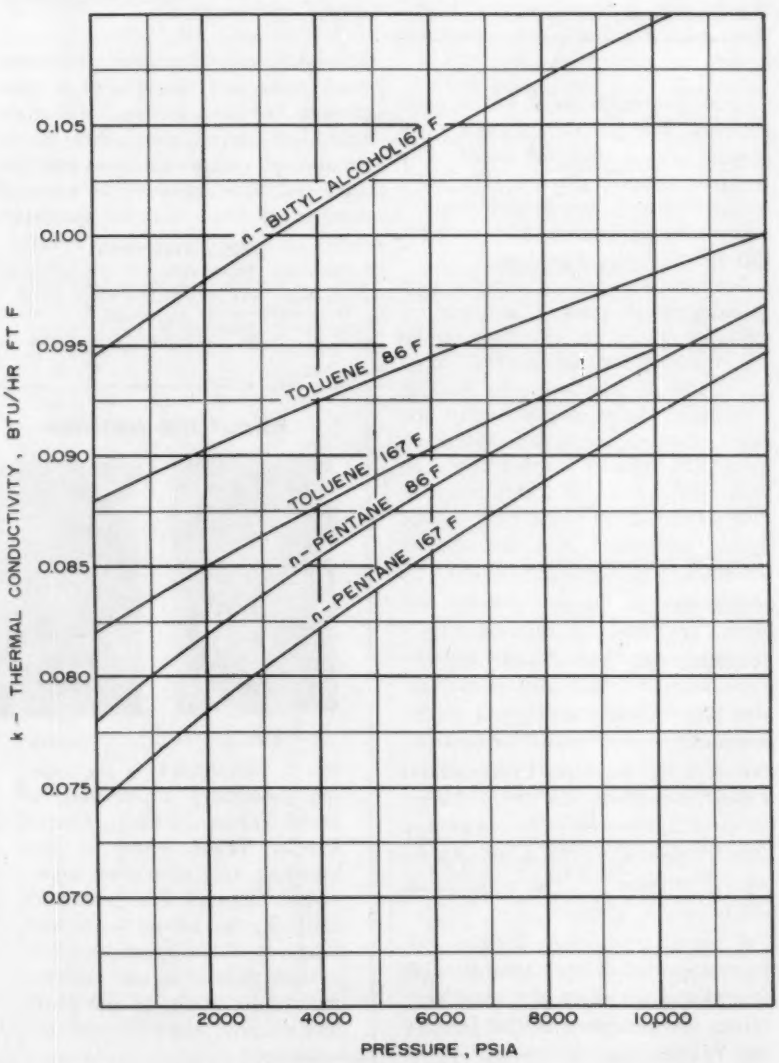

FIGURE 1—Liquid thermal conductivities. Effect of pressure on thermal conductivities.

exceeds the rate of change of density with pressure. The ratio of thermal conductivities along an isotherm can be expressed as

$$\left(\frac{k_2}{k_1}\right)_T = \left(\frac{\omega_2}{\omega}\right)^m = \frac{\varepsilon_2}{\varepsilon_1} \qquad (2)$$

The term, m, is an exponent greater than one to account for the larger change of thermal conductivity with pressure, and ε, equivalent to ω^m, is the conductivity-factor.

Equation 2 can be used to predict thermal conductivities, where ε is correlated by reduced temperature and reduced pressure. The best agreement with experimental data occurs when the value of m is computed by the relation,

$$m = -2.94\,T_R + 3.77 \qquad (3)$$

Watson's expansion factors for density combined with Equations 2 and 3 allow the computation of conductivity-factors. Figure 2 and the equivalent Table 1, show the resulting computed conductivity-factors used for correlation with the equation,

$$\left(\frac{k_2}{k_1}\right)_T = \frac{\varepsilon_2}{\varepsilon_1} \qquad (4)$$

Equation 4 is valid only when k_2 and k_1 are at the same temperature.

To illustrate the validity of Equation 4 and Figure 2, Table 2 compares predicted values of thermal conductivity at high pressure with the measured values of Bridgman,[1] Sellschopp,[2] and Uhlir.[3] The Bridgman values represent measurements obtained at 14.7 pounds per square inch absolute and at a series of pressures in excess of 10,000 psia. To get Bridgman values at pressure less than 10,000 psia, the measured results were plotted on large-size graph paper, and values of thermal conductivity interpolated from the smooth curve at the 2000, 4000, 6000, and 8000 psia pressure levels. Table 2 shows the average arithmetic prediction deviation to be 1.6 percent, with a maximum deviation of 5.3 percent for Argon near its critical point. If it were assumed that no change in thermal conductivity

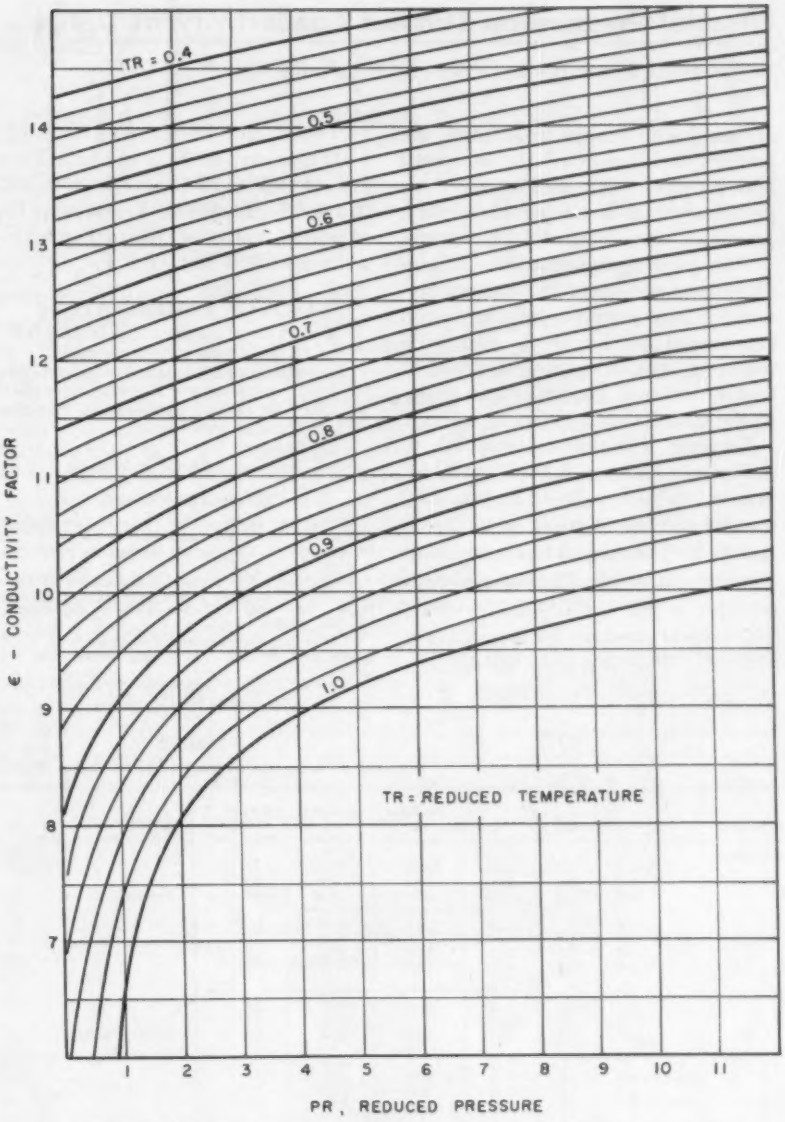

FIGURE 2—Generalized chart for liquid thermal conductivities. Effect of pressure.

TABLE 1
Conductivity-Factors

Reduced Pressure	REDUCED TEMPERATURES							
	0.4	0.5	0.6	0.7	0.8	0.9	0.96	1.0
0	14.25	13.39	12.42	11.40	10.14	8.10	6.98	....
1	14.39	13.54	12.61	11.62	10.47	9.10	7.96	7.10
2	14.52	13.68	12.78	11.82	10.76	9.61	8.74	8.09
3	14.64	13.81	12.93	12.01	11.00	9.96	9.15	8.61
4	14.75	13.93	13.06	12.16	11.20	10.21	9.44	8.95
5	14.85	14.04	13.19	12.31	11.38	10.43	9.67	9.18
6	14.95	14.15	13.30	12.45	12.45	10.61	9.85	9.38
7	15.04	14.24	13.41	12.56	11.69	10.76	10.00	9.53
8	15.12	14.32	13.50	12.67	11.81	10.89	10.15	9.67
9	15.20	14.41	13.59	12.77	11.92	11.00	10.28	9.79
10	15.28	14.49	13.67	12.85	12.02	11.09	10.40	9.89
11	15.35	14.56	13.75	12.93	12.10	11.17	11.00	9.99
12	15.42	14.63	13.82	13.00	12.15	11.25	11.10	10.08

occurred with change in pressure, the average deviation of the measured high-pressure values from the low-pressure values is 8.6 percent, with a maximum deviation of 18.4 percent.

The good agreement between predicted and measured thermal-conductivity values justifies the correlation represented by Figure 2. The wide range of temperatures and types of liquids indicate general applicability of the correlation.

Example: The thermal conductivity of liquid n-pentane at 86 F. and 14.7 psia is 0.0780 Btu/hr ft F. We need the thermal conductivity at 4000 psia and 86 F. The critical temperature of n-pentane is 855 R. The reduced temperature is $(86 + 460)/855 = 0.645$. The critical pressure for n-pentane is 479 psia. The reduced pressure is $4000/479 = 8.35$. From Figure 2, at 14.7 psia and 86 F., $\varepsilon = 12.00$. At 4000 psia, and 86 F., $\varepsilon = 13.15$. Then $k_{4000} = 0.0780(13.15)/12.00 = 0.0855$ Btu/hr ft F. From Figure 1, the measured value of thermal conductivity is 0.0854 Btu/hr ft F.

TABLE OF NOMENCLATURE

k	Thermal conductivity, Btu/hr ft F.
m	Exponential correction term
T_R	Reduced temperature—operating temperature, Rankine, divided by critical temperature, Rankine
ε	Conductivity-factor
ρ	Density
ω	Expansion-factor of Watson

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About the Author

J. M. LENOIR received his Ph.D. degree from the University of Illinois in 1949. He spent four years as an assistant and associate professor at the University of Arkansas, and two years at the University of Denver. He has been an engineer for American Oil Company, Texas City, and is presently associated with C. F. Braun and Co., Alhambra, Calif.

TABLE 2
Study of Accuracy of Conductivity-Factor Methods

LIQUID	T_R	P_R	ε	Predicted k	Measured k	Percent Dev.
n-Pentane[1]	.645	....	11.96	....	0.0780	....
	.645	4.2	12.68	0.0826	.0819	0.9
	.645	8.3	13.15	.0857	.0855	0.2
	.645	12.5	13.50	.0881	.0885	—0.5
	.740	....	11.02	....	.0742	....
	.740	4.2	11.81	.0796	.0785	1.4
	.740	8.3	12.36	.0832	.0822	1.2
	.740	12.5	12.76	.0860	.0856	0.5
Toluene[1]	.511	....	13.30	....	.0880	....
	.511	3.3	13.75	.0909	.0902	0.6
	.511	6.5	14.09	.0930	.0924	0.7
	.511	9.8	14.38	.0950	.0945	0.5
	.627	....	12.12	....	.0820	....
	.627	3.3	12.68	.0856	.0850	0.7
	.627	6.5	13.10	.0885	.0877	0.9
	.627	9.8	13.40	.0906	.0904	0.2
Ethyl Ether[1]	.650	....	11.91	....	.0795	....
	.650	3.8	12.57	.0836	.0840	—0.5
	.650	7.7	13.05	.0870	.0878	—0.9
	.650	11.5	13.87	.0924	.0913	1.2
	.745	....	10.88	.....	.0780	....
	.745	3.8	11.70	.0840	.0825	1.8
	.745	7.7	12.25	.0880	.0864	1.9
	.745	11.5	12.58	.0903	.0900	0.3
Methyl Alcohol[1]	.591	....	12.51	....	.1218	....
	.591	1.7	12.82	.1249	.1259	—0.8
	.591	3.5	13.09	.1270	.1295	—1.9
	.591	5.2	13.30	.1292	.1331	—2.9
	.591	6.9	13.47	.1310	.1367	—4.2
	.679	....	11.60	....	.1194	....
	.679	1.7	11.96	.1230	.1239	—0.7
	.679	3.5	12.27	.1261	.1280	—1.5
	.679	5.2	12.52	.1290	.1320	—2.3
	.679	6.9	12.72	.1310	.1353	—3.2
Ethyl Alcohol[1]	.586	....	12.52	....	0.1048	....
	.586	4.3	13.18	0.1100	0.1122	—2.0
	.586	6.5	13.44	.1122	.1158	—3.3
	.586	8.6	13.63	.1140	.1190	—4.2
	.675	....	11.65	....	.1006	....
	.675	4.3	12.43	.1072	.1081	—0.8
	.675	6.5	12.72	.1100	.1117	—1.5
	.675	8.6	12.93	.1118	.1150	—2.9
Butyl Alcohol[1]	.542	....	13.00	....	.0966	....
	.542	5.6	13.76	.1022	.1023	—0.1
	.542	8.4	14.03	.1043	.1048	—0.5
	.542	11.3	14.25	.1060	.1072	—1.1
	.622	....	12.22	....	.0945	....
	.622	5.6	13.08	.1010	.1012	—0.2
	.622	8.4	13.37	.1031	.1040	—0.9
	.622	11.3	13.60	.1051	.1069	—1.7
Acetone[1]	.596	....	12.42	....	.1036	....
	.596	5.8	13.28	.1068	.1100	—2.9
	.596	8.7	13.56	.1091	.1127	—3.2
	.596	11.6	13.79	.1110	.1157	—4.0
	.685	....	11.60	....	.0976	....
	.685	5.8	12.59	.1060	.1038	2.1
	.685	8.7	12.90	.1088	.1064	2.3
	.685	11.6	13.13	.1108	.1090	1.6
Carbon Disulfide[1]	.556	....	12.82	....	.0925	....
	.556	3.6	13.35	.0962	.0976	—1.4
	.556	5.4	13.55	.0976	.1000	—2.4
	.556	7.1	13.74	.0990	.1021	—3.1
	.638	....	12.02	....	.0875	....
	.638	3.6	12.63	.0920	.0934	—1.5
	.638	5.4	12.88	.0936	.0960	—2.5
	.638	7.1	13.07	.0950	.0985	—3.6
Water[1]	.474	....	13.56	....	0.3480	....
	.474	1.25	13.75	0.3530	.3540	—0.3
	.474	1.9	13.84	.3555	.3565	—0.3
	.474	2.5	13.91	.3565	.3595	—0.8
	.543	....	13.00	....	.3720	....
	.543	1.25	13.20	.3780	.3780	0.0
	.543	1.9	13.29	.3800	.3820	—0.5
	.543	2.5	13.38	.3825	.3860	—1.0
Nitrogen[3]	.80	1	10.47	....	.0601	....
	.80	2	10.76	.0618	.0626	—1.2
	.84	1	10.01	....	.0546	....
	.84	2	10.33	.0565	.0578	—2.2
	.88	1	9.47	....	.0489	....
	.88	2	9.88	.0510	.0525	—2.8
	.92	1	8.70	....	.0431	....
	.92	2	9.31	.0462	.0482	—4.1
	1.00	2	8.09	....	.0398	....
	1.00	1	6.60	.0325	.0325	0.0
Argon[3]	.88	0.5	9.19	....	.0395	....
	.88	1	9.47	.0418	.0425	—1.6
	.88	2	9.88	.0425	.0449	—5.3
	1.00	1.3	7.35	....	.0309	....
	1.00	2	8.09	.0340	.0340	0.0
	1.00	1	6.60	.0278	.0278	0.0
	.81	0.5	10.18	....	.0477	....
	.81	1	10.36	.0486	.0500	—2.8
	.81	2	10.65	.0500	.0517	—3.3
Carbon Dioxide[2]	.94	0.75	8.10	....	.2017	....
	.94	1.15	8.50	.2120	.2132	—0.6
	.95	0.77	7.90	....	.1908	....
	.95	1.12	8.28	.2000	.2040	—2.0

Automation Today Part 11

Here are the factors to consider before asking the computer to simulate a refining process.

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OFTEN, THE NUMBER of computations required to examine a control system properly are too cumbersome or complicated to handle by conventional means. It is then that electronic computers can be used to carry out these tasks.

Computers have already been applied or seem soon to be applied to three separate tasks related to automatic process control. These are: (a) the computer simulation of processes; (b) reduction of plant instrument data; and finally (c) actual plant control or plant control direction. The problems raised in Parts 2, 9, and 10 of this series are all included in item (a) since they each entail the use of a computer to represent the action of a process under the influence of a given upset or in a given control situation. That is, the computer's action "simulates" the action of the process. It is this task which is the subject of the present article. The other tasks listed have been described to some extent elsewhere[7] and will be discussed more thoroughly in subsequent articles of this series.

Simulation defined in another way from that above is the art of "programming" or wiring the various components of a computer (usually an analog computer) together in such a manner that the differential equations which could be written for the computer system which is thus formed are as closely as possible the same as those of the physical system we wish to study. The system to be considered is generally both the mechanism we are investigating and the associated control devices which we wish to apply, as we saw in Parts 9 and 10. Therefore, the group of differential equations comprising our mathematical model usually includes equations defining the action of the control devices as well as the equations defining the mechanism under study.

In the case of the computer, the dependent variable which we wish to observe is the voltage at the output of any one of the several computing elements involved. Since the differential equations of the two devices are to be the same in form, any variation of these voltages represents directly the corresponding variations in the dependent

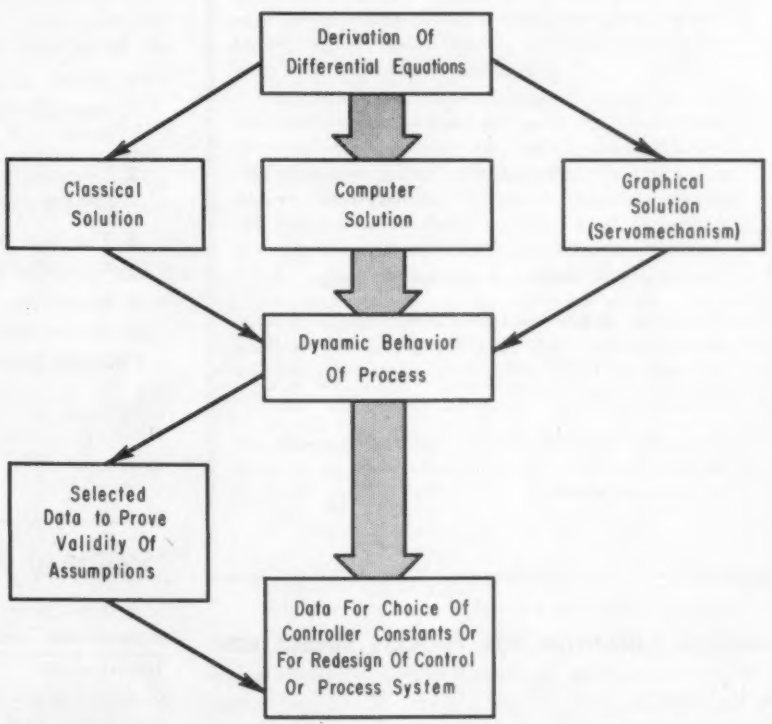
Derivation Of Differential Equations
Classical Solution
Computer Solution
Graphical Solution (Servomechanism)
Dynamic Behavior Of Process
Selected Data to Prove Validity Of Assumptions
Data For Choice Of Controller Constants Or For Redesign Of Control Or Process System

FIGURE 63—Here are some of the steps in applying the technique of computer simulation to process problems.

variable of the system under study at the corresponding locations in that system.[6] For example, if one were simulating a physical spring, mass, damper system with the analog computer, voltage in the computer would represent displacement in the physical system. Then the variation of voltages in the computer would be exactly analogous in magnitude, frequency of oscillation, and the amount of damping present to the corresponding variation of the displacement of the mass in the physical system.

In addition, we can impose voltages onto the input of the model system on the computer which will represent any desired external influence on our actual physical system. Furthermore, since the computer is protected by its design features from damage due to excessive voltages (i.e., by fuses and circuit breakers), we are free to determine, if we desire, just how severe a disturbance the control system can correct, the effects of controller instability, or even, if desired, the limits of the corresponding physical system before actual physical damage or destruction would occur. Thus, the utility of a technique such as this is self-evident.

These Assumptions May Simplify Process Control Simulation

1. It is impossible with present day equipment to make an exact simultation of a process which requires partial differential equations to express it. The simultation must be made on the "lumped-parameter" system which most closely resembles the actual physical system. Since the action of a lumped parameter system is assumed to occur at a series of discrete locations rather than to be distributed uniformly through the process, it can now be represented by a family of simultaneous ordinary differential equations. See Part 10. Representation of these on the computer is then relatively easy.
2. Usually the process is assumed to be adiabatic with its surroundings. Not only does this simplify the computer representation but is usually the most efficient configuration in any case.
3. Heat capacity effects of vessels and retaining walls are assumed negligible. This is usually done to conserve computing equipment.

ANALOG COMPUTER FOR PROCESS SIMULATION

Figure 63 outlines graphically the steps which would be involved in applying the technique of computer simulation to process problems. Let us take each of these up in turn. We will discuss the pertinent factors involved at each stage and show the particular advantages of the analog computer and any special precautions which are necessary for its use.

Derivation of Equations. Due to its design, the usually available analog computer, the electronic differential analyzer, is especially adapted to the solution of ordinary differential equations.[1] Our first task is, therefore, to develop a mathematical model of our process system which is compatible with the capabilities of the machine. This mathematical model must, therefore, be a family of one or more ordinary differential equations. However, in contrast to the classical methods of solution of differential equations, we are not limited here to linear equations, nor are we prevented from the use of families of simultaneous equations.

As a first step in developing the necessary equations, it is recommended that one first draw the "block diagram" of the system or process in question as described in Part 1. The block diagram by representing each basic element of the process in its correct relationship to the rest reduces the process to its simplest terms and thus helps assure that the correct differential equation will be developed.[4]

The next step in the development of the system equations, once the block diagram has been drawn, is to list the various assumptions which one wishes to make concerning the system under study. Assumptions are used either to assign a probable value or relation to an otherwise unknown function and thus permit the development of our equations, or as simplifying factors to reduce a too complex system to one which is within the capabilities of the available computing equipment. Some simplifying assumptions which are often made are given in the accompanying box.

As an example in the heat exchanger which we discussed in Part 9, Figure 52, the following assumptions (all of the simplifying variety) were made:

1. Perfect mixing and thus a uniform temperature throughout occurs in each of the shell side compartments, a, b, c, d, and e.
2. Likewise, perfect mixing occurs in each of the tube side compartments, a′, b′, c′, d′, and e′.
3. The heat transfer coefficient is constant throughout the exchanger and is independent of temperature.
4. Heat capacity and intersectional transfer of heat by the metal walls of the exchanger are negligible.

Once the problem has been completely stated by drawing the block diagram and by specifying the defining assumptions, as well as the simplifying assumptions, it is relatively easy to write the required differential equations to complete our mathematical model. These usually con-

You May Want to Review These Earlier Parts

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sist of a series of expressions of the laws of conservation of mass and energy, of rates of heat transfer and chemical reaction, and of fluid motion within the process.

Solutions of Differential Equations. Once we have developed the differential equations we are ready to carry out the actual computer simulation. If the equations are linear and simple enough, they can, of course, be solved by the well known classical means or by the newer graphical techniques inherent in the science of servomechanisms An example of this latter is the use of the Bode diagram as outlined in Part 6.

However, most chemical and petroleum process systems, especially when the necessary instrumentation and control systems are added, are very much nonlinear. In addition, since most of these processes are multi-stage or must be assumed so, because of the lumped parameter assumption previously mentioned, their mathematical models are families of simultaneous equations. Thus, the classical and graphical solution methods cannot be used. Also, these latter methods of solution by the very nature of their use nullify one of the basic advantages of the art of simulation, as we shall see.

Since a computer is necessary, let us consider the relative advantages of the analog over the other basic type, the digital computer, for the task we wish to perform. In order to keep the record straight one should list at the same time the disadvantages of analog machines. This is done in the accompanying box.

EXPERIMENTAL DETERMINATION OF DATA

Of course, this same response data could have been obtained on the physical system itself, without the necessity for any of the simplifying assumptions which we have mentioned as necessary for computer solution, provided we have the proper instrumentation. However, there are several disadvantages entailed in a purely experimental approach. These are given in the following list:

1. Most plant equipment is needed for normal production. Its use for experimental testing would thus necessitate its being kept off-stream for the period of time involved.
2. Much plant equipment is quite large and thus uses a sizeable inventory of material for operation. Since a majority of materials are relatively high priced, a large investment in plants and inventory is necessary.
3. Large scale plant equipment is usually quite sluggish in its responses; therefore, a larger amount of experimental time would be necessary to completely determine the response of the equipment to a variety of input disturbances.
4. Since response testing involves testing the stability of the plant system to various inputs, the possibility is always present of causing an instability and even damage to the system.
5. Each actual piece of plant equipment can only be tested over a limited range of variables possible in its operation; therefore, a complete test of a class of apparatus might necessitate the testing of several different

Using An Analog Computer for Process Simulation

ADVANTAGES

1. The analog computer by solving differential equations continuously permits a direct analogy between various components of the computer and the corresponding parts of the process. The digital computer solves these equations at discreet intervals by arithmetic means. Thus, there is no direct relationship between the computer components and those of the process system.
2. The analog computer normally presents its results as a family of graphs of the variations of the dependent variable of the process at various chosen locations within the simulated process versus time. This is, of course, the same type of data as would be obtained if a recording device were connected to the actual physical process which is being simulated. Most digital computers, on the other hand, present their results as tables of numbers. These must be plotted before they attain the utility of the analog solutions just described.
3. The analog computer solves its problem at a speed which is a direct function of the actual speed with which the real physical system would carry out the same variations. This speed is independent of the size or complexity of the system being simulated. The digital computer solution speeds, on the other hand, are a direct function of problem complexity and size and relatively independent of the actual speed of operation of the physical system.
4. The analog computer is usually programmed so that the magnitudes of the various parameters of the problem being solved are entered as settings on variable potentiometers. The investigator, therefore, has the liberty of changing the values of these parameters almost at will. This is especially valuable in "tuning" a control system by means of computer simulation or as an aid in process design, since the effects of various parameter changes are easily and quickly determined by means of the process of "knob twiddling." This facility is not conveniently present in digital computer solutions unless special programming precautions are taken.
5. Analog computers are generally much cheaper for an equivalent class of computer, although this factor is very hard to evaluate directly.

DISADVANTAGES

1. The complexity of the problems which are solvable on any particular analog computer is a direct function of the size of the computer itself or rather of the number of computing components which it contains. It is, therefore, relatively easy to visualize problems which are too large for any particular analog computer. Indeed, it is often true that the size of problem which it is necessary for one to solve is of this type. Then one is forced to make simplifying assumptions to reduce the complexity of the problem if the problem is to be solved at all. In the digital computer problem size is reflected in computing time. Therefore, nearly any problem can be solved if one is willing to take the necessary time.
2. The analog computer is specifically designed for the solution of ordinary differential equations, and it is very inefficient in attempting to solve any other class of problem. This is in contrast to the digital computer which has utility in nearly all types of mathematical problems. The analog computer should be procured, therefore, only when one has sufficient process control or process transients work to justify it economically.

apparatuses of various sizes and configurations to complete the investigation.

The most serious and the ones which would probably prevent our ever obtaining a complete knowledge of chemical process behavior by purely experimental means are No. 3 and No. 5. For example, the investigation of the automatic control of a continuous distillation column recently carried out by the author and his co-workers required approximately 1200 separate computer solutions.[3,5,6] This required six weeks of analog computer time. Carrying out the same investigation on an actual distillation column would require several years, if it were ever carried out at all. The same comparison can be made for nearly every complete computer study reported in the literature.

There remains, however, the question of the simplifying assumptions of which we have repeatedly spoken in our discussions of equation derivation and computer solution. Their presence certainly cast a doubt upon the validity of our computer results. This doubt can only be resolved when experimental evidence shows that either the assumptions we made were correct or that any detrimental effect introduced by them is negligible. The proof of the assumptions for one example of a particular class of chemical processes will serve to prove these same assumptions for almost all succeeding examples of the same class of processes. Also, we need not make a complete study of the actual physical system upon which we are checking the assumptions involved in a computer system. A few critical conditions chosen from among the computer results will serve to prove the validity of the complete computer results if verified by experiment.

Real time simulation is one solution to the problem of the simplifying assumptions which are often involved in computer solutions versus the experimental collection of data. By this we mean that the operating speed of the computer is adjusted so that it is the same as that of the process or device being simulated.

In this case, components of the real or physical system can be actually connected into the computer mechanism. The only additional requirement to accomplish this is that the proper transducers must be available to convert the operating variable of the process element into a voltage which can be used by the computer elements which represent the rest of the process loop.

As an example of such a case, one might consider the problem of determining the applicability of a particular pneumatic controller to a chemical reactor. The reactor can then be simulated on the computer and the controller connected into the computer system by voltage to pressure and pressure to voltage transducers. Now we can adjust the controller directly and determine what setting gives the best control of particular reactor situations as simulated by the computer.

The analog computer texts cited[1,2] discuss more fully how this technique is actually accomplished in practice.

USING ANALOG COMPUTER DATA

The analog computer quickly turns out such a mass of data that its proper correlation, interpretation, and use soon becomes a problem. If the input condition on the computer is a sinusoidal function, and if various frequencies are imposed, a modification of the graphical techniques of servomechanisms is a very useful and direct way of using the data.[4]

However, the stepwise variation of the input function such as was used in the tests carried out on the heat exchanger described in Part 9, is a much more specific test of the responses of control systems, particularly when nonlinear elements are present. A direct method of presenting the results of such tests is therefore needed.

A control system tied to a process which is then subjected to a stepwise input condition can give essentially three responses. First, it can give a satisfactory control; second, it may cause a damped oscillation to be set up; or last, it may be inadequate to its task and allow the process to become unstable. By noting these results for various settings of any two of the three controller constants, K, K′, and K″, we can then plot a graph with coordinates of one constant versus the other and thus define areas on the graph for which the controller gives each of the three types of response. From such a graph the allowable controller settings are then indicated. Such a graph is of most value when some optimum control combination can also be indicated from computer solution and shown on the graph. This technique is especially valuable when a family of such curves can be made up for various values of the third control variable. We will thus completely define the control relationship. Such a set of graphs was shown in Part 9 for the heat exchanger problem we considered there.

It appears, therefore, that the analog computer through the techniques of simulation can obtain for the industry in the cheapest and quickest possible manner the data it needs for the following problems, among others:

1. The most probable reaction mechanisms and kinetic parameters of our processes by computer evaluation of laboratory data.
2. The optimum control system for both present and future processing equipment.
3. The optimum reactor and other plant equipment designs from the standpoint of dynamic behavior and automatic control.
4. The optimum scheduling and operating conditions for both batch and continuous reactors to assure maximum yields.

It should also be kept in mind, however, that the analog computer has some definite limitations as a general purpose computer for chemical and chemical engineering problems; and its procurement by a particular company should be justified on the basis of a contemplated workload in the fields of automatic process control and of chemical process transients only.

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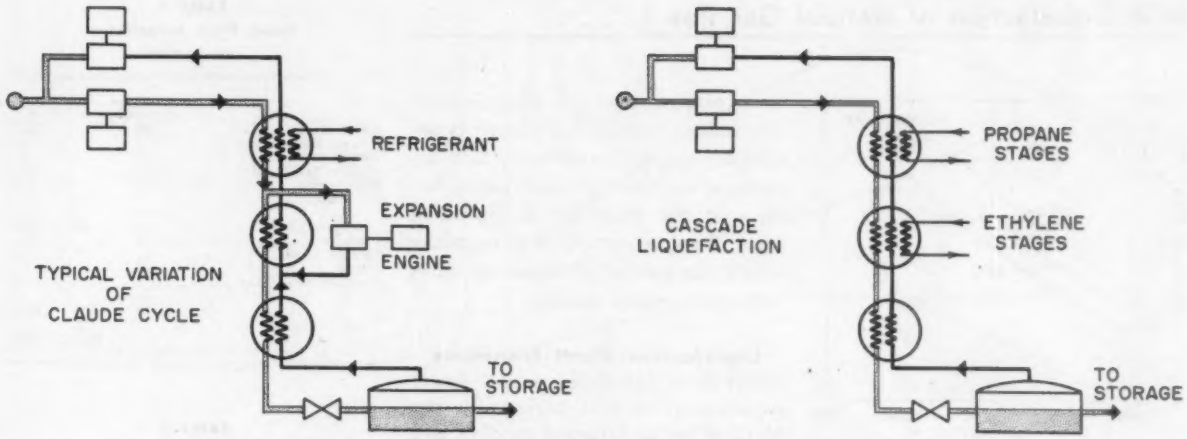

FIGURE 1—Liquefaction cycles: Cascade type was chosen for this study.

Will Liquefaction of Natural Gas Pay?

This study shows how much it will cost to liquefy natural gas at cheap sources and ship it to New York and the North Sea.

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NEW INTEREST HAS DEVELOPED in the use of additional gas sources. One of the most promising methods appears to be the liquefaction of the natural gas at or near its source for transportation to fuel-poor areas. This study shows what it will cost.

The major sources of natural gas are the Gulf Coastal area of the United States, the Persian Gulf area, and Venezuela, with minor fields in Italy, France, Pakistan and several other countries. Only the United States has developed its natural gas resources to any great extent for fuel purposes, with pipe lines as the means of moving the fuel to the markets.

Owing to large over-water distances, movement by pipe line is impractical or virtually impossible if natural gas is to be supplied to the fuel-poor areas of the world from the fields where it is presently vented or returned to the reservoir. Liquefaction with its inherent advantage of a 600-fold reduction in volume per heating unit appears to be a good method of processing the natural gas for movement over water, and in some cases might be competitive with pipe lines in moving overland.

In examining the economics of the liquefaction process for transporting, storing and supplying gas, the costs can be broken down into three major categories: liquefaction, transportation and storage. The cost of liquefaction is chiefly dependent upon the compressor requirements, while the latter two are functions of distance from source to market and the efficiency with which both tankers and land storage are utilized.

To get a proper economic perspective, it is necessary to examine various liquefaction capacities and typical cycles; that is, refrigeration schemes, in addition to the various factors which influence shipping and storage costs.

There have been many types of cycles studied for liquefaction processes,[29] and their suitability varies with temperature level and equipment available. As can be seen from bubble point plots such as Figures 2 and 3, the liquefaction temperature is a function of the natural gas composition and its pressure. The presence of ethane and heavier components will allow liquefaction at higher temperatures than is possible with pure methane, while helium or nitrogen in the gas will have the opposite effect. It appears also, that for most natural gases, ethylene in the cascade must be used as a refrigerant if vacuum is to be avoided at compressor suctions.

In order to produce liquid for storage at atmospheric pressure, with the accompanying temperatures in the neighborhood of —260 F., auto refrigeration will be necessary. At the present time, it appears that the most economical cycle available is the propane-ethylene-methane (natural gas) cascade cycle. There may be situa-

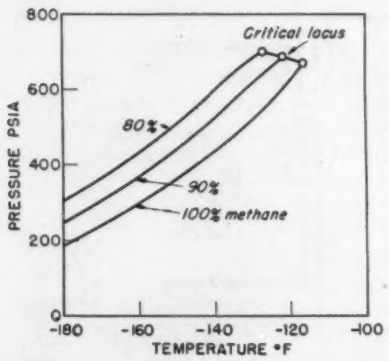

FIGURE 2—Bubble points of methane-nitrogen mixtures: High nitrogen content requires lower liquefaction temperatures.

tions where other cycles prove to be more economical and it will be necessary to examine each case individually.

The choice of a cycle and the necessary power required for liquefaction depend on the particular properties of the gas being processed. It is beyond the scope of this paper to study the effect of cycle variation on the overall economics.

As a basis of design, a propane-ethylene-methane cycle will be utilized, as shown in the simplified flow diagram (Figure 1) and all the power requirements will be based on liquefying pure methane available at 800 pounds per square inch with a 75 percent adiabatic compressor efficiency and a 10 F. temperature approach in the exchangers. Figure 1 also shows a version of the Claude cycle in which

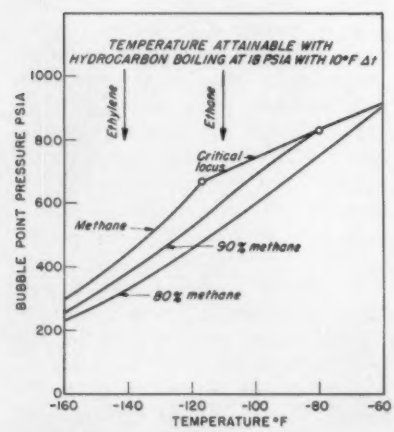

FIGURE 3—Bubble points of methane-ethane mixtures: Ethane content affects liquefaction the opposite way.

an expansion engine is used to reach low temperatures. This scheme is potentially as good as or better than the cascade system for some gases, but its economic feasibility is dependent upon the development of an expander which can handle gas-liquid mixtures with considerable quality.

Liquefaction Plant Economics—Based on a calculated actual power requirement of 0.51 horsepower per Mcfd of gas as liquefied product and the standard methods of pretreatment three plants with capacities of 100, 250, 400 MMcfd were estimated, with total costs indicated in Figure 4. The costs, Table 1, include a 30 percent increase for construction overseas. The major cost item in the plant is in the compressors and because of this the plant investment per unit of capacity will be quite stable, Figure 5. Since land and utilities and other items can vary widely depending on the particular location and gas composition, an average value was used in all cases.

It would appear that due to the large investment in compression equipment, it would be wise to concentrate on methods of reducing power requirements. However, due to the other large capital items, a saving of 10 percent in power requirements will only reflect an over-all saving of about 4 percent.

A close examination of the manufacturing costs, Table 2, reveals that the overriding item is depreciation which accounts for about 40 to 50 percent of the cost depending on the cost of the raw material. Since another one-fourth of the total liquefaction cost is attributable to other fixed and relatively stable costs, the plant must operate with a high load factor to keep the unit cost within reason. Thus, the cost of liquefaction (approximately $0.14 per Mcf liquefied for the specified condition) is relatively insensitive to plant capacities.

Storage and Transportation Costs—The investment in storage and shipping facilities, including a regasification plant, will amount to a little over half of the total capital required (Table 1). Efficient use of both the tankers and storage equipment, as well as efficient design will be necessary so that the whole operation will be economically feasible.

In order to obtain the cost of trans-

TABLE 1
Fixed Plant Investment
(400 MMCFD)

	Millions of Dollars		%
Compressors	65		27
Process Equipment	7		3
Buildings	7		3
Utilities and Land	9		4
Engineering	6		2.5
Contractor	5		2
Plant Cost	99	99	(41.5)
Tankers	79		33
Storage Tanks	31		13
Docks	4		1.7
Regasification Plant	4		1.7
	118	118	(49.5)
Contingency		22	9
Total		$239	(100)

TABLE 2
Annual Plant Operating Costs
(400 MMCFD)

	$ X 10³	%	
Raw Material (4¢/MCF)	4,200	18.5	
Labor (inc. Supervision)	600	3	
Maintenance*	1,300	6	
Power (Gas) (4¢/MCF)	80	1	
Other Utilities	15	1	
Direct Mfg. Costs	$ 6,195		(27)
Payroll and Plant Overhead	710	3	
Depreciation (10 years amortization)	12,000	53	
Insurance	1,200	5	
Administration, Sales and Research	2,600	11	
	$22,705		

* Basis—$5.00 per H.P. installed for compression equipment plus $1.20 per H.P. installed for general maintenance.

In order to obtain the cost of trans-

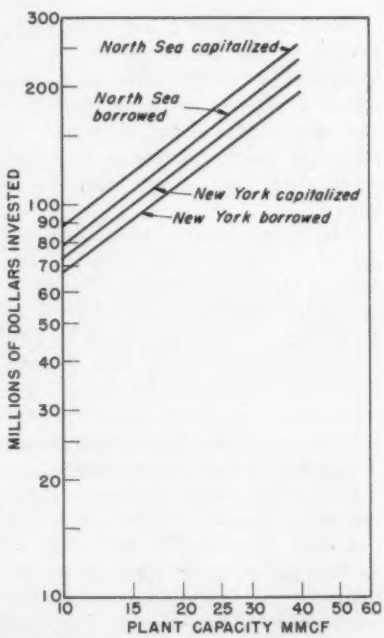

FIGURE 4—How total fixed capital investment varies with plant capacity.

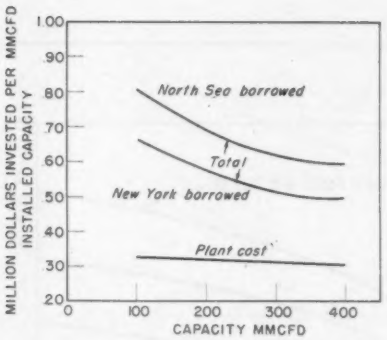

FIGURE 5—Invested capital per unit of capacity is quite stable.

TABLE 3

Source and Market Possibilities Studied

SOURCE	Market	Distance (Nautical Miles)
Gulf Coast	New York	1900
Gulf Coast	North Sea	2500
Venezuela	New York	1800
Venezuela	North Sea	2100
Persian Gulf via Suez	New York	9000
Persian Gulf via Suez	North Sea	6500
Persian Gulf via Cape	New York	11000
Persian Gulf via Cape	North Sea	11600

portation and storage, combinations of sources and markets in several areas were studied as shown in Table 3. The cost and investment will vary with tanker size and speed, as well as the distance from source to market.

In a recent comprehensive study by H. A. Benford[21] of tanker economics, as indicated in Figure 6, it is shown that the optimum tanker speed in most situations will be about 16 knots and this speed was used. In order to evaluate the effect of tanker size, ships with capacities of 700, 900, 1100, and 1400 MMcf were considered. The optimum combination of ships and storage tanks was arrived at on the basis of lowest over-all shipping and storage costs. In this phase the amount of capital required again plays a very significant part in determining the operating cost, since depreciation accounts for about 40 percent of the shipping and storage costs, based on a twenty year amortization.

The investment required is based on building at least five tankers of the same design in foreign shipyards and a cost of $10 per Mcf of land storage. At the present time, this cost may be low, since foreign yards have a backlog of tanker orders which should carry them over the next several years, and it may be necessary to build in the U. S. with its higher construction costs, Figure 7.

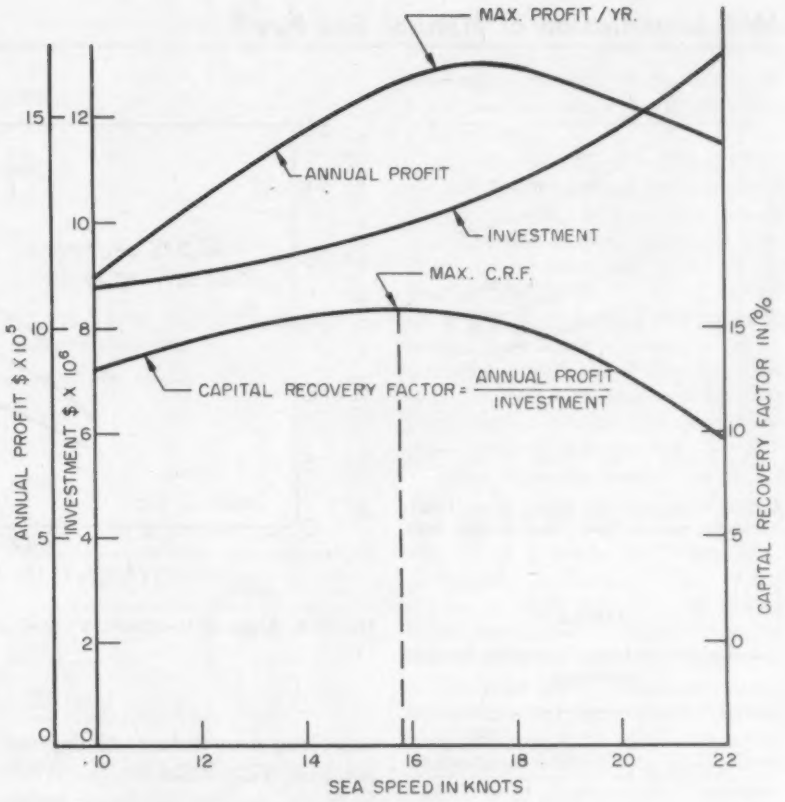

FIGURE 6—Optimum tanker speed is about 16 knots (40,000 DWT, after Bedford).

TABLE 4

Annual Tanker Operating Costs
(Venezuela to New York or Great Britain)
(1400 MMCF Capacity)

		%
Crews' Wages†	$388,000	47
Overhead (incl. Insurance)†	64,000	7
Stores and Subsistance†	60,000	8
Maintenance†	152,000	18
Fuel* (@ 17¢/MCF)	166,000	20
Total	$830,000	

* Cost of fuel for ships operating from Gulf Coast is $330,000. Cost of fuel for ships operating via Suez is $276,000.

† Method of Benford (Ref. 21).

TABLE 5

Number of Tanker Trips Per Year
(Tanker Speed, 16 Knots)

FROM	TO New York	TO North Sea
Venezuela	28	13
Gulf Coast	28	11
Persian Gulf (via Suez)	6.3	8.3
Persian Gulf (via Cape)	4.6	5.1

The lowest possible shipping cost will be achieved by keeping the large tankers at sea as much of the time as possible, since under American registry the crews' rates are fairly constant regardless of the tanker capacity and represent a major portion of the tanker operating cost, Table 4. There is very little reduction in the cost of operating the tankers should they be partially idle, or partially full. A high load factor, just as is necessary in pipe line operation, will be necessary in order to provide economical transportation of the product.

It is quite obvious that the distance from source to market will be a significant factor in the final delivered cost of the product as well as the total investment required to deliver a given amount a year. Table 5 lists the average number of trips that tankers with speeds of 16 knots can complete annually. It will, therefore, take twice as many tankers to service the North Sea area from Venezuela or the U. S. as it will the New York area.

Similar analogies can be drawn for any combination of source and mar-

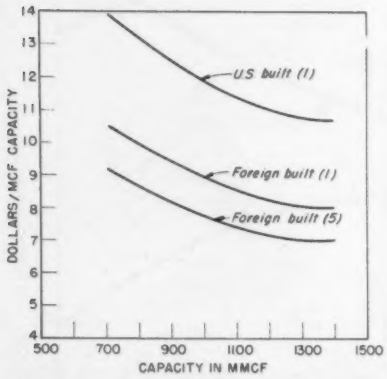

FIGURE 7—Relative tanker costs (Spring, 1956): It would pay to have them foreign built.

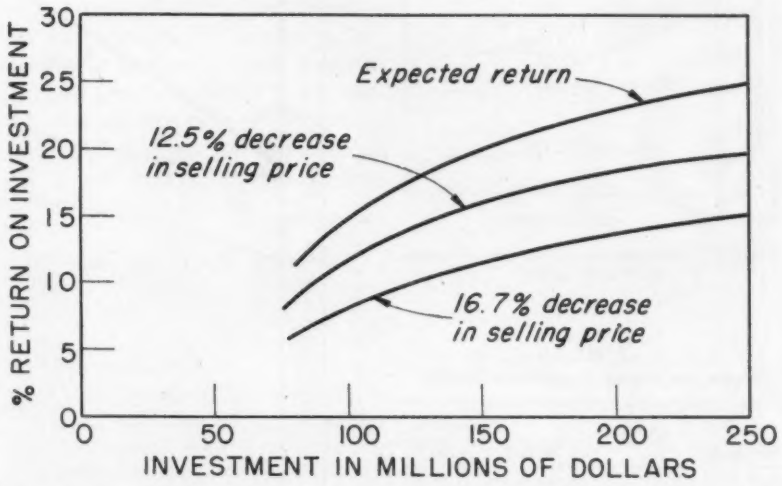
% RETURN ON INVESTMENT
INVESTMENT IN MILLIONS OF DOLLARS
Expected return
12.5% decrease in selling price
16.7% decrease in selling price

FIGURE 8—Return on investment: It's based on a hypothetical raw material cost of $0.04/MCF.

TABLE 6

Relative Cost of Tanker Operation Per Unit Delivered

FROM	TO New York	TO North Sea
Venezuela	1	2.2
Gulf Coast	1.2	2.8
Persian Gulf (via Suez)	5.9	4.3
Persian Gulf (via Cape)	7.0	6.2

ket, as indicated in Table 6 which shows the relative costs of shipping a unit of product between various points. In addition to the shipping costs as such, there will be a corresponding increase in the investment required in tankers, since the effective yearly capacity of each tanker is inversely proportional to the number of trips completed.

Unless there is an overriding price differential either in raw material costs, as will be the case when Venezuela and the Gulf Coast are considered as sources of supply, or selling price, as may be the case when competitive pricing in different areas such as New York or Great Britain takes effect, it is important to operate in markets as close to the source of supply as possible.

The charge made for fuel to the ships may have some effect on the over-all economics. The use of some natural gas as a fuel seems indicated, since some of the cargo will be vaporized during the trip. Unless used as fuel or re-liquefied on board, it will be lost. The fuel, in the present case, was charged at the cost of liquefaction plus raw material charges. It may be more advantageous under certain circumstances to re-liquefy the gas and to use residual fuel oil instead.

For example, if the tanks are emptied and allowed to warm on the return voyage there will be a loss of liquid in the cooling process and, in addition it will be necessary to safeguard against excessive thermal shock. It appears wise to leave sufficient liquid in the tanks to maintain low temperature and utilize the evaporated gas for fuel to supplement or replace fuel oil. This will depend on the particular situation and bears further study.

In the study all estimates were based on liquefaction of all of the products at one installation and delivery to only one point. It may be desirable to deliver to several points, thereby eliminating some of the risk involved in basing the operation on a single market. In such a case, delivery costs will probably increase by between 5 and 10 percent per added delivery point depending on the particular situation.

The Competitive Situation—The cost of liquefying and delivering natural gas to the point of consumption on a continuous basis will vary with plant capacity to a small degree and with distance to market to a larger degree. For the largest plant, liquefying 400 MMcfd of gas and using the most economic combination of tankers and storage, within the limits studied, the cost of processing, that is, liquefying and delivering the natural

CASE STUDY I

Gas for East Coast Delivery—100% Load Factor

(~400 MMCFD Demand)

Processing Coast	$0.13 per MCF
Transportation and Storage	0.08
Incremental Cost	$0.21
Raw Matrial Cost	$0.04—0.25
Delivered Cost	$0.25—0.46
Expected Selling Price	$0.60/MCF
Investment Required	$220,000,000

CASE STUDY II

Great Britain Delivery—100% Load Factor

(~400 MMCFD Demand)

Processing Coast	$0.13 per MCF
Transportation	$0.13 per MCF
Incremental Cost	$0.26
Raw Material Cost	$0.04—0.25
Delivered Cost	$0.30—0.51
Expected Selling Price	$0.80
Investment Required	$240,000,000

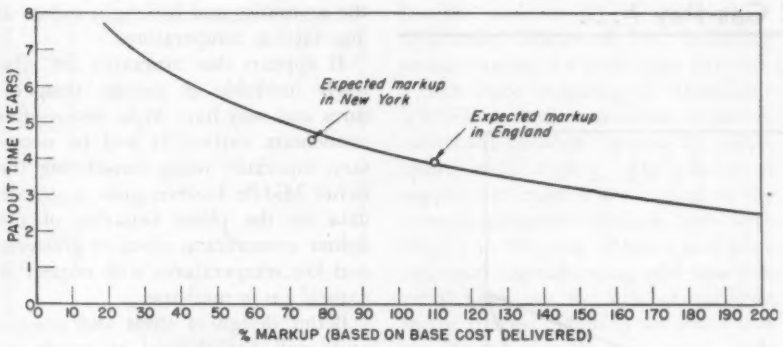

FIGURE 9—How payout time varies with mark-up.

gas from either the Gulf coast of the United States or Venezuela to the New York area or Great Britain will be 21 cents and 26 cents per Mcf respectively, according to Case Studies I and II, exclusive of interest or taxes. Interest charges, should the capital be borrowed at the rate of 4 percent, will be about 6 cents per Mcf.

At the present time it would appear that liquid natural gas is competitive as a means of supplying fuel in the North Sea area and in all probability in the northeastern United States, Table 7, if a source of natural gas can be found where the cost of the raw material is cheap.

The maximum profitability is obtained by the largest investment studied, a 400 MMcfd plant shipping to Europe. With an estimated competitive price of 80 cents per Mcf a payout time of about three years can be expected based upon the extremely low, perhaps unrealistic, price for raw material of 4 cents per Mcf.

This payout period will be altered significantly with either a decrease in selling price or an increase in raw material cost. Should the raw material cost 20 cents per Mcf, for example, the payout time would be about 3.6 years. If the capital required to build the facilities is borrowed instead of being raised through an issue of stock, the interest charges would have marked effect on the profitability.

In order to better evaluate the profitability of various investments, Figure 8 and 9 show the payout period and return on investment for the various possibilities studied at a raw material cost of 4 cents per Mcf. The raw material cost of 4 cents per Mcf was chosen as the cost of obtaining

TABLE 7

Cost of Fuels

(Cost Per Equivalent MCF)

	Great Britain	New York
Coal	$0.50	$0.40
Fuel Oil	1.10	0.875
Natural Gas	.....	0.60
Manufactured Gas	1.00	.....
Atomic Energy (present) (est.)	3.60	.....
Atomic Energy (1960) (est.)	1.10	1.20
Atomic Energy (1970) (est.)	0.80	0.75

Sources: Wall Street Journal; American Gas Association; Battelle Technical Review, July, 1956; Nucleonics, May, 1956; United Nation Statistical Yearbook, 1955.

vented gas in the vicinity of the liquefaction plant and for which no market exists.

It's conceivable that the costs of exploration, development and collecting gas might be as high as 50 cents per Mcf in the near future in some areas. Such costs would, naturally, be repeated in the final delivered cost of liquid and where possible in pipe line delivered cost.

At the present time peak load shaving is a problem faced by practically all utilities and it has been hoped that liquefied natural gas could alleviate this problem, as it did in its first application in Cleveland in the early 1940's. Peak load shaving with natural gas liquid appears to be an attractive possibility if the liquefaction plant and tankers can be kept operating at or near 100 percent of capacity the year around.

The cost of the natural gas, as indicated in Case Study III, to take care of a 3600 MMcf annual peak load duty is about $1.20 per Mcf. This clearly indicates the effect of not having a high turn over of stored liquid and it will therefore be necessary to treat each case separately.

The price quoted compares favorably with most other methods of peak load shaving, Table 8, in use today. Unfortunately there is a strong indication that plants of the capacities discussed cannot expect to operate at full capacity on peak load demands and must depend on a large percentage of their production being utilized in continuous load applications.

Technological Gaps—In order to achieve further savings through more

CASE STUDY III

Peak Load Shaving

Total annual peak load duty		3600 MMCF
Maximum Monthly Demand		1200 MMCF
Storage Required		1200 MMCF
Annual Requirement (to cover heat losses)		6200 MMCF
Investment		
Storage at market @ $10/MCF		$12,000,000
Allocated Storage at plant		$ 6,000,000
Total (not including shipping)		$18,000,000
Depreciation (@ 5%)	$ 900,000	
Operating Expenses—Tankers	$ 500,000	
Other operating expenses	$1,500,000	
Sub total	$2,900,000	$2,900,000
Cost of liquid gas f.o.b. plant @ $.17/MCF (6,200 MMCF)*		$1,050,000
Gross cost		$3,950,000
Credit for Losses to line @ $.40/MCF		$1,000,000
Net Cost		$2,950,000
Unit Cost (not in profit) 0.85/MCF		

* (Based on raw material charge of $0.04/MCF).

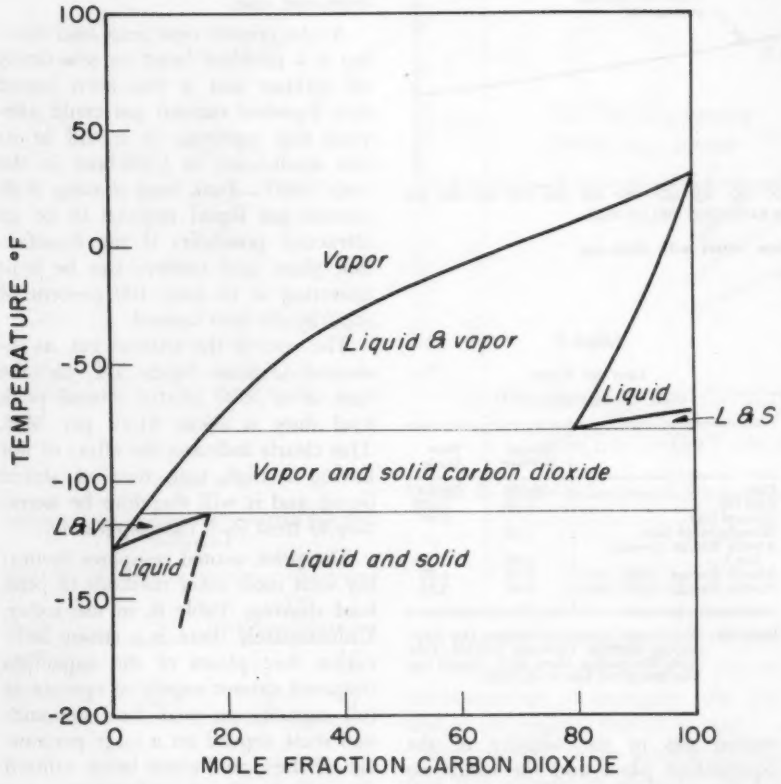

FIGURE 10—Carbon dioxide-methane system at 500 psia (after Donnelly): How much carbon dioxide can be allowed.

TABLE 8

Approximate Peak Load Shaving Costs

	Cost per MCF
Oil Gas	$0.80—$1.00
Liquid Natural Gas	~$1.20
Propane*	~$1.50
Demand Pipeline Gas*	as high as $4.80

* **Source**—Ref. 23.

efficient design there is a definite need for more technical data and, improved and cheaper materials of construction. There is a very definite need for better thermal data for natural gas and its constituents at elevated pressures and low temperatures.

This data should include specific heat data in general; but specific heat data in the high pressure region near the critical point of the Molier diagrams and heats of solution are especially important.

Although good correlations of vapor-liquid equilibrium ratios are available, it is still necessary to obtain specific phase behavior if operation near the critical point is anticipated. Research programs now in progress will soon present data to help in closer design of expansion valves and heat exchangers.

There is some question as to the allowable limit of carbon dioxide in the gas at liquefaction temperatures. Donnelly's data, Figures 10 and 11, indicate that amine scrubbing will be sufficient,[8] but further data would be helpful in this area to check the extended curves presently used. Carbon dioxide is not the only compound which may cause difficulty at extremely low temperatures. There is some evidence that the lighter paraffins are soluble in methane, but there is great doubt as to the behavior of the aromatics and hydrogen sulfide at liquefaction temperatures.

It appears that aromatics are relatively insoluble at storage temperatures and may have to be removed as condensate earlier. It will be necessary, especially when considering the richer Middle Eastern gases, to obtain data on the phase behavior of the lighter aromatics at elevated pressures and low temperatures with respect to natural gas or methane.

Better design of ships and storage units will not depend so much on improved physical data, or improved data on the low temperature characteristics of metal where information is quite adequate. It will depend on finding materials which will act both as insulators and liquid barriers and satisfy the demands of the rigid safety standards necessary at sea and in the storage areas. At the present time it appears that inner alloy steel tanks surrounded by insulation will be necessary to contain the liquid during shipment.

A vessel with only insulation and no second tank would not only be cheaper but would have a greater capacity in all probability. Permanent storage facilities will also be cheaper if better insulating materials can be found that will eliminate the extensive use of alloy steel. There is room for improvement in design to achieve savings, but this will only be possible with additional technical data and better materials of construction.

Enhancing Profitability—Since it appears rather difficult to decrease production and delivery costs, it may

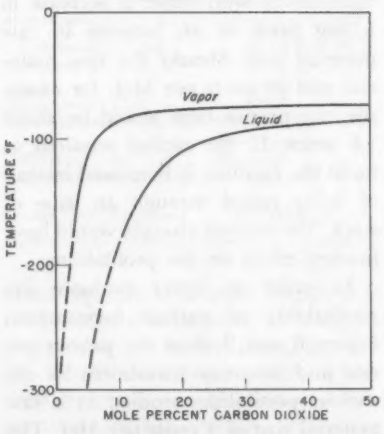

FIGURE 11—Composition of phases in equilibrium with solid carbon dioxide. More data is needed to check the extended curves.

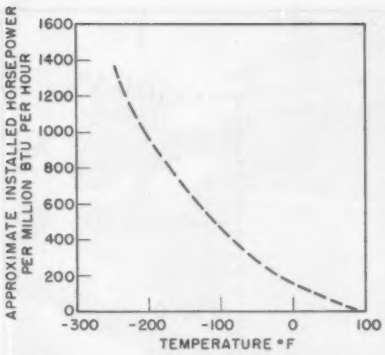

FIGURE 12—Power required to reach and provide refrigeration at given temperatures: It may be profitable to liquefy selective fractions at various temperatures before liquefying the major portion.

be wise to invest in equipment to enhance the value of the products. At present there is a demand for ethane, propane, and butane at premium prices for use as chemical raw material and fuel. Once the gas has been liquefied, it is comparatively easy to separate the various components by standard fractionating techniques at a small additional cost.

In addition nitrogen can be readily removed by this method, allowing a fuel of the highest possible heating value to be shipped. It may be profitable to carry this one step further and liquefy selective fractions at various temperatures before liquefying the major portion at —260 F., since it requires much less power, (Figure 12), to deliver refrigeration at temperatures not quite as low as those required for total liquefaction.

It has been suggested several times that recovery of the available refrigeration in the liquid natural gas at the point of regasification would enhance the profitability of this type of venture. Credit attainable from refrigeration recovery is very much dependent on the particular area where the regasification takes place, and although it definitely is worth investigation, it should not become the criterion for going ahead or stopping a venture of this type.

There is a definite need for additional fuel in certain areas of the world today and this demand appears to be steadily climbing. Atomic energy will no doubt carry part of this load, but there is more than enough room for the development of liquefied gas production. It appears that the liquefaction of natural gas for transportation and storage is economically feasible and should be competitive with most sources of fuel, including atomic energy, for some time to come.

The basic technological know-how is available and most of the improvements will enhance the over-all profitability only slightly. The choice of supply and market are critical in the over-all economic picture, both with respect to shipping distance and price structure since shipping and raw material costs are the critical variables in the process. There is no doubt that gas liquefaction bears careful study as a profitable venture to utilize fuel presently vented or returned to the ground.

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The advice of Prof. Harry Benford of the University of Michigan, Department of Naval Architecture and Marine Engineering in discussing tanker design is appreciated.

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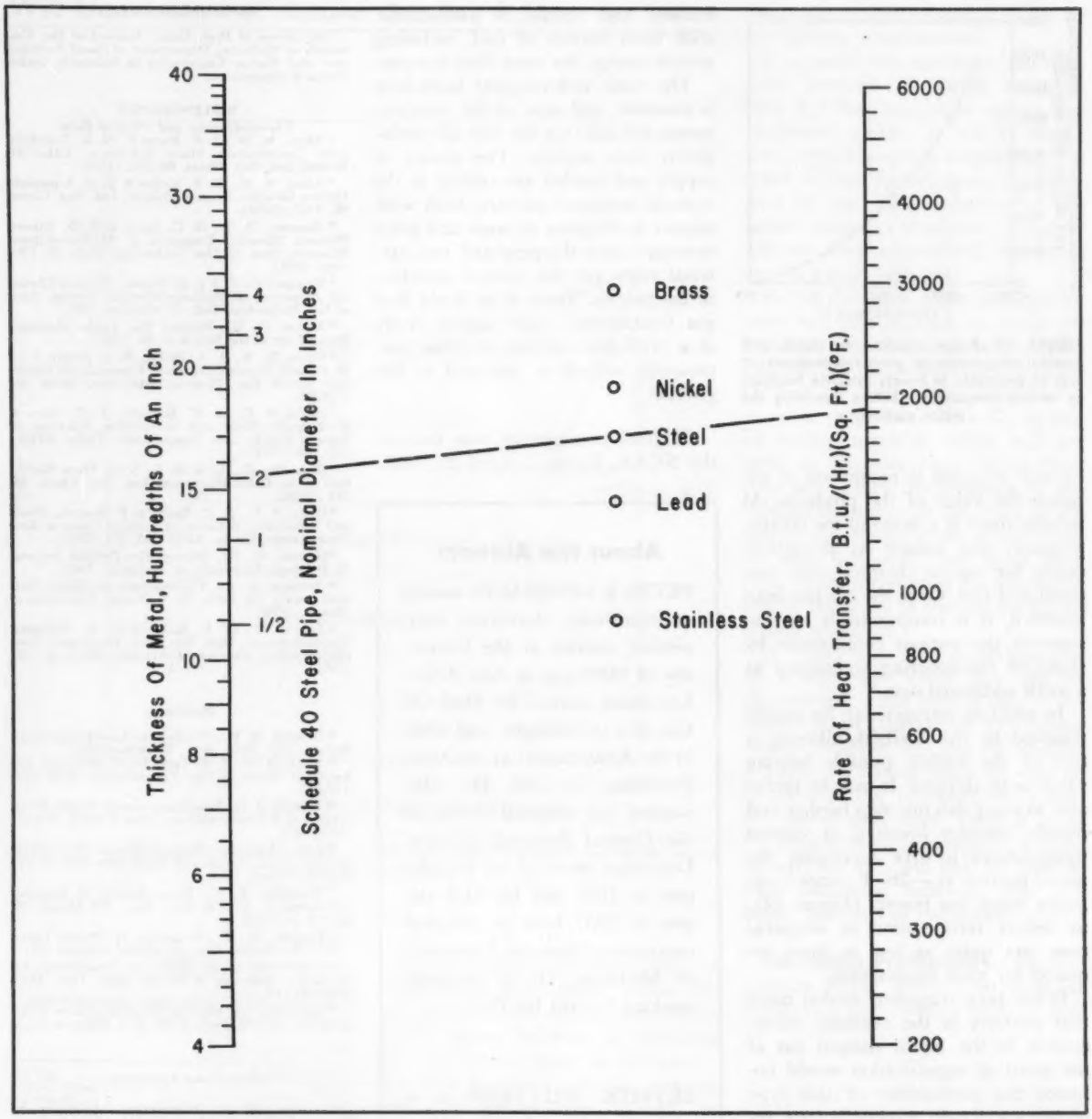

Heat Transfer for Pipes

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Tuscaloosa, Alabama

THE ACCOMPANYING line coordinate chart presents in convenient form data[1] that deal with heat transfer through the metal walls of pipes and tubes. The vertical numbers on the scale at the left are for thickness of metal in hundredths of an inch or for the nominal diameters of Schedule 40 steel pipe.

The use of the nomogram, which was constructed by means of well-known methods[2] is illustrated as follows:

What is the heat transfer rate through the walls of 2-inch Schedule 40 steel pipe?

Connect 2 on the scale at the left and the circled point for steel with a straight line; read the intersection with the scale at the right as approximately 1900 Btu/(hr.) (sq. ft.) (°F.).

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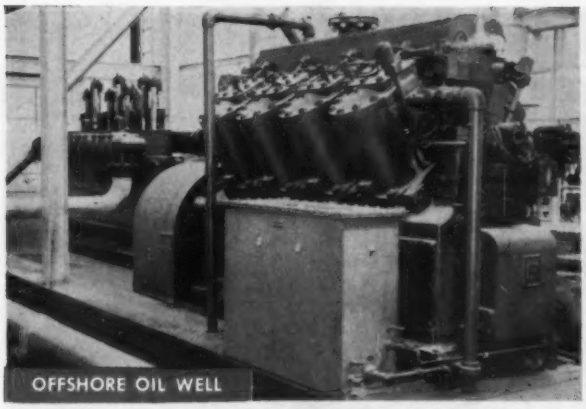
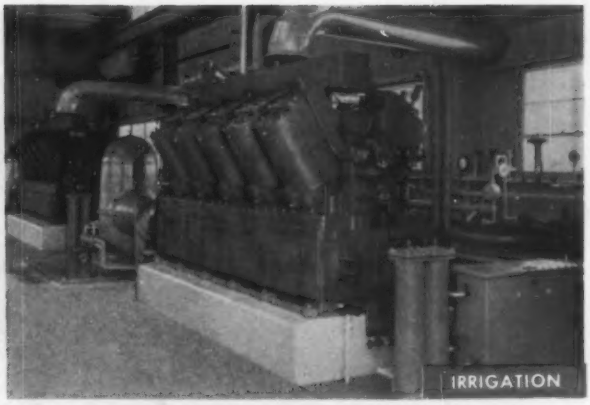
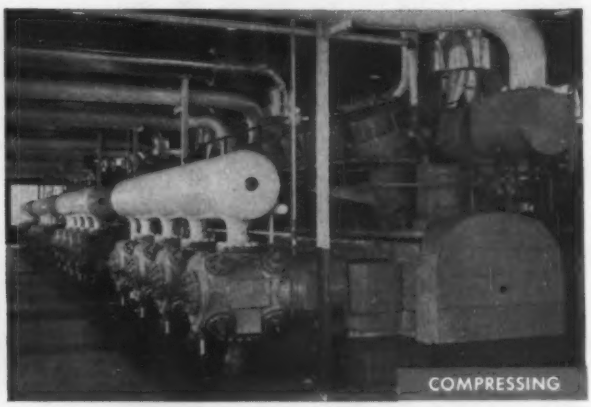


This 295-hp PJVG gas engine is mounted on a platform in the Gulf of Mexico driving a reciprocating crude oil pump. PJVG engines are built in 220 and 295-hp sizes.



The 680-hp PSVG units above are driving Ingersoll-Rand centrifugal pumps on a large irrigation project. PSVG gas engines cover the 408-816-hp range.

This 1100-hp PKVG is shown at the task most frequently assigned to I-R power units: a-c generator drive is a natural for smooth-running I-R 4-cycle gas engines. PKVG's are available from 880 to 1760 hp.



All I-R gas engines are also offered in integrally-built engine-compressor units. Above are 2000-hp turbo-charged KVS compressors on gas transmission. 4-cycle engine-compressors are available from 120-2000 hp.

POWER for any purpose

gas engines deliver heavy-duty power economically

Whatever the task, Ingersoll-Rand heavy-duty 4-cycle gas-engine equipment offers the highest dependability, flexibility and long-run economy. Built for 24-hour-a-day, continuous operation on a wide range of fuels, these engines are especially suitable where close control is important (such as a-c generator drive). Where I-R power units and their companion engine-compressors are used together, the similarity of operation and the interchangeability of parts effects additional important economies. Contact your I-R representative now for more information.

4-CYCLE

Ingersoll-Rand

6-491

11 Broadway, New York 4, N.Y.

COMPRESSORS • GAS AND DIESEL ENGINES • ROCK DRILLS • PUMPS • TURBO-BLOWERS • AIR AND ELECTRIC TOOLS

For more data on advertised products, use Readers' Service Cards, last page.

The Future of Smog

Every four years, a population increase the equivalent of a city the size of Pittsburgh, is added to Los Angeles County. To prevent this growth from adding to the already man-sized air pollution problem, officials have come up with a program that will eliminate air pollution by future industry. You'll want to read how this plan is going to work, plus what the oil industry has already done to eliminate the present smog problem. It's all there for you, so just .....

Keep Going to Page 230

News Flashes!

That's all you get when you read "Changing Times," the section that presents the news after it has been boiled until just the bare essentials remain. It's fast moving—it's quick—and above all, it's accurate. See for yourself.

Keep Going to Page 239

Inspecting Equipment

One book reviewed this month is "Guide for Inspection of Refinery Equipment," which is a new publication announced by the Refining division of API. Specifically, it deals with "Conditions Causing Deterioration or Failures," and "Inspection of Atmospheric and Low Pressure Storage Tanks." You'll want to read the review of this new book, so .....

Keep Going to Page 180

First in Canada

The first Canadian chemical process plant for the production of petroleum sulphonates has been placed into operation by Surpass Petrochemicals, Ltd. This month's "Who's Building" tells you all about that plant and how it operates. There are also many, many other construction capsules that give the highlights of building projects all over the world. You can read them all when you .....

Keep Going to Page 190

CNGA Elects

The newly elected president and members of the board of the California Natural Gas Association assumed their duties last month at the annual board of directors meeting in Los Angeles. You'll get the complete list of the board members plus who the new president appointed as standing committee chairmen. This and many more items will be of interest to you as you read, "What's Happening Among Men in the Industry."

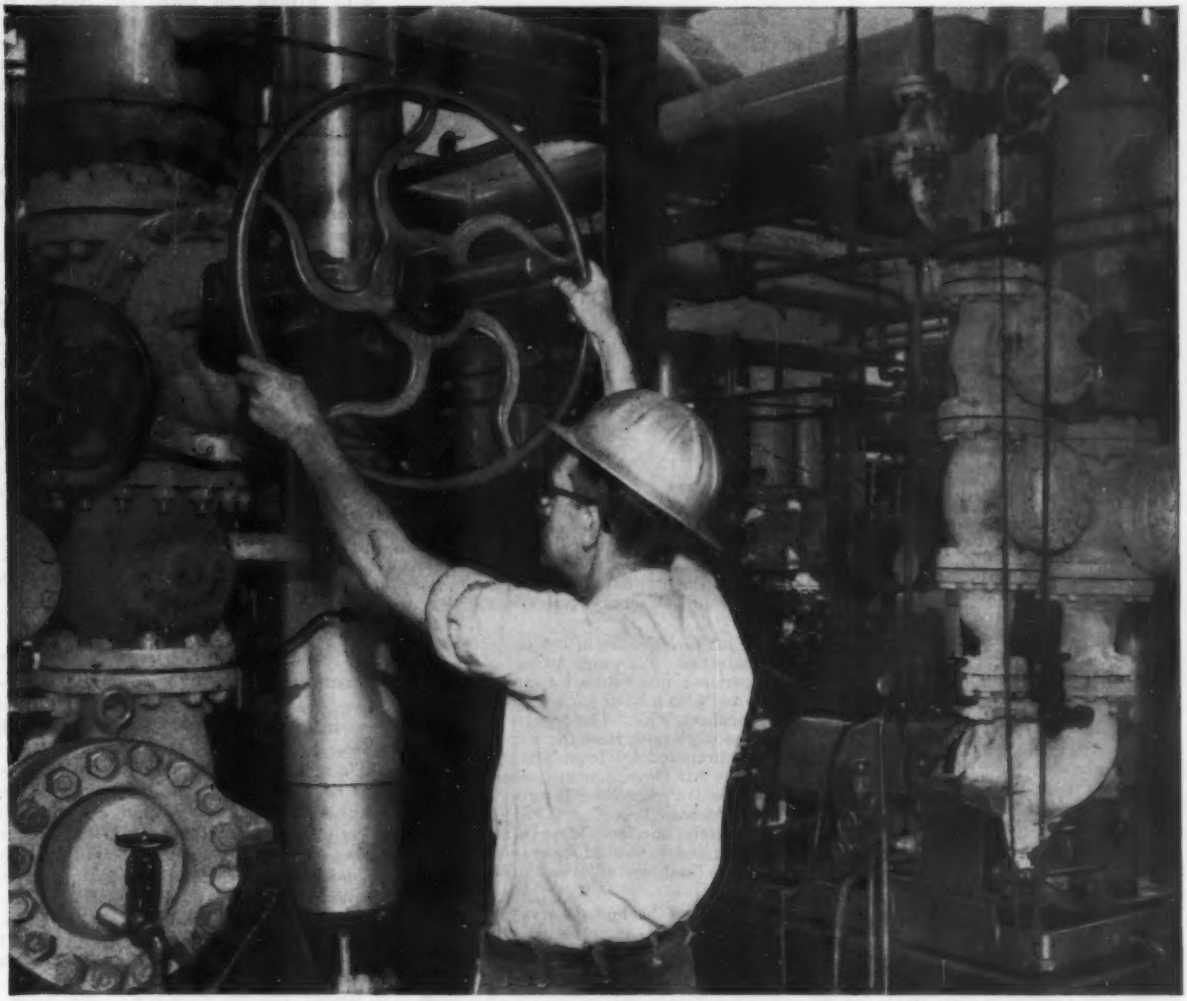
Keep Going to Page 242

Want to Know More?

Anytime you want to know a little (or a lot) more information about advertised products or items of "New Equipment," all you have to do is use the green "Readers' Service Card" enclosed just inside the back cover. If you have never tried it, do so this month. It's put there just for you.

Keep Going to Page 287

Another Refinery Saves with Crane Steel Valves



14 years on 680° F. bottoms handling ... still no repairs on these valves

These 300-pound Crane steel gates and checks were installed in The Cities Service Refinery Corporation at Lake Charles, Louisiana in 1943.

Installed in the "A" topping unit, on discharge line from bottoms pump, they're still leak-free . . . show no sign of seat damage.

For 14 years these valves have handled this tough 680° F. service with no more attention than routine maintenance at turnarounds. Once-a-week operation at this high temperature hasn't affected their original smooth and accurate seating action.

In Crane Exelloy, these valves have a highly developed seating material for handling hot oil and oil vapor. It has excellent resistance to corrosion, wear and temperature effects. Teamed with Crane steel castings, it assures durable valve service on recommended applications.

Get complete facts on Crane steel valves with Exelloy trim from your Crane Representative, or write to address below.

IDEAS FOR YOU in this book of "Valve Performance Facts." Your Crane Man has a copy for you.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill.—Branches and Wholesalers Serving All Areas

Reviewing New Books . . .

Guide for Inspection of Refinery Equipment

New publications announced today by the Division of Refining of the American Petroleum Institute include Chapters II and XIII of the Guide for Inspection of Refinery Equipment.

Chapter II deals with "Conditions Causing Deterioration or Failures." It covers the more frequently encountered conditions which cause deterioration and failure of refinery equipment, including corrosion, erosion; high temperature effects on subnormal temperature effects; causes and effects of excessive pressures; and faulty material and equipment. A description of common refinery metals and alloys is appended.

Chapter XIII of the Guide for Inspection of Refinery Equipment deals with "Inspection of Atmospheric and Low-Pressure Storage Tanks." It contains a description of the design and construction of atmospheric and low-pressure storage tanks; reasons for inspection and causes of deterioration; recommendations on frequency and time of inspection; and procedures and tools required for inspection of tanks in service and out of service and of auxiliary equipment.

(American Petroleum Institute, 50 West 50th St., New York. Chapter II, 60 pages of text, 59 illustrations. Chapter XIII, 41 pages of text, 68 graphic illustrations, $2.00 each.)

"The Design and Construction of Liquefied-Petroleum-Gas Installations at Marine and Pipeline Terminals, Natural-Gasoline Plants, Refineries and Tank Farms."

Known as API Standard 2510, this manual is the result of several years of work by the API Committee on Liquefied Petroleum Gas, of which George R. Benz, of Phillips Petroleum Co., Bartlesville, Okla., is chairman. It was designed to fill a specific gap in LPG Standards, the API said, explaining:

"In the Standards developed by the National Fire Protection Association for the storage and handling of liquefied petroleum gases, marine and pipe line terminals, natural gasoline plants, refineries, and tank farms were excluded.

"Since these installations are large in size or closely associated with operating units or both, they represent a more complex problem and require a wider latitude for the designer than installations covered by the National Fire Protection Association.

(API 50 West 50th Street, New York 20, N. Y., $1.00.)

"Rubber" fundamentals of its science and technology

This book covers the entire rubber industry, including synthetic elastomers, latices of both natural and synthetic rubbers, and even the pertinent plastics.

Utility is the keynote of the book. With judicious selection from the latest developments in rubber chemistry and physics, theories of elasticity, vulcanization, accelerators, reinforcement, antioxidants, etc., and the most up-to-date procedures of rubber technology and testing, it provides a well-balanced, concise but comprehensive treatise on this vital commodity.

(Chemical Publishing Co., Inc., 212 Fifth Ave., New York, N. Y., 464 pages, $12.00. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

"The Chemical Formulary" Vol. X

This new volume is a collection of new, up-to-date formulae. Some of the chapters relating to the petroleum industry are those dealing with lubricants, oils, rubber, resins, plastics, and waxes. The book contains many other formulae of a general nature such as paints, paper, photography, insecticides, weed killers, and many others.

When the method of formulation is important, emphasis is placed on the cares to be taken. Thus the book gives some know-how in the field of chemical formulation.

(The Chemical Publishing Co., 212 Fifth Ave., New York, N. Y., 392 Pages, $8.00. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

"Analysis of Variance: Preliminary Tests, Pooling, and Lineal Models."

Guidelines for the application of analysis of variance, the statistical aid to design and analysis of experiments and interpretation of experimental data, are provided in these two technical reports just released by Air Force.

A major objective of the project was the preparation of a guide to use of analysis-of-variance procedures by research investigators "with modest backgrounds in mathematical statistics." The reports of two parts of the work both have the same title. They were prepared by Iowa State College for Wright Air Development Center. They are: Volume I: Preliminary Tests of Significance and Pooling Procedures for Certain Incompletely Specified Models, and Volume II: Derived Linear Models and Their Use in the Analyses of Randomized Experiments.

(Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., Volume I, 148 pages, $3.75, order PB 121333. Volume II, 132 pages, $3.50, order PB 121334.)

Methods of Testing Small Fire Extinguishers.

Although several types of small hand-portable fire extinguishers have been available for combating fires of flammable liquids, their relative effectiveness has not been widely understood. Tests have indicated that their performance differed greatly.

The study was performed by H. Shoub, T. G. Lee, and J. M. Cameron, of the National Bureau of Standards. They evaluated the effectiveness of the extinguishers using five different extinguishing agents on ten types of fires. The work is sufficiently broad to be applicable to many types of small liquid fires.

(Order National Bureau of Standards Building Materials and Structures Report 150, from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 9 pages, 15 cents.)

(NOTE: Foreign remittances must be in U. S. exchange and should include an additional one-fourth of the publication price to cover mailing costs.)

"The Physics of Flow Through Porous Media"

In writing this book, Dr. Adrian E. Scheidegger made a thorough search of the world literature, including that from behind Iron Curtain countries. Therefore, a number of topics are presented for the first time in book form. There is a complete discussion of the past and present physical theories of flow through porous media, including a theoretical deduction of Darcy's law, a critical evaluation of the Kozeny theory, and a presentation of statistical flow theories.

This book expounds the theory of the advance of a saturation front in the displacement of a fluid in a porous medium by another which is immiscible with the first, and gives a complete theory of displacement of a fluid in a porous medium by another which is *miscible* with the first. It outlines methods for solutions of flow problems for turbulent flow, molecular flow, and flow with adsorption, in addition to reciting briefly the standard methods applicable to cases where Darcy's law is valid.

(The Macmillan Co., 60 Fifth Ave., New York 11, N. Y., $14.00, 236 pages. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

"Hydrogen Absorption, Embrittlement and Fracture of Steel,"

written by Arnold E. Schuetz and W. D. Robertson, this report of a 4-year research project sponsored by the National Association of Corrosion Engineers has been published. The illustrated report covers a research project sponsored by NACE's Technical Committee T-1G on Sulfide Stress Corrosion which was paid for by contributions of industries interested in so-called spontaneous fracture of steel.

(NACE Publication 57-17, National Association of Corrosion Engineers, 1061 M & M Building, Houston 2, Texas, 24 pages, $2.00.)

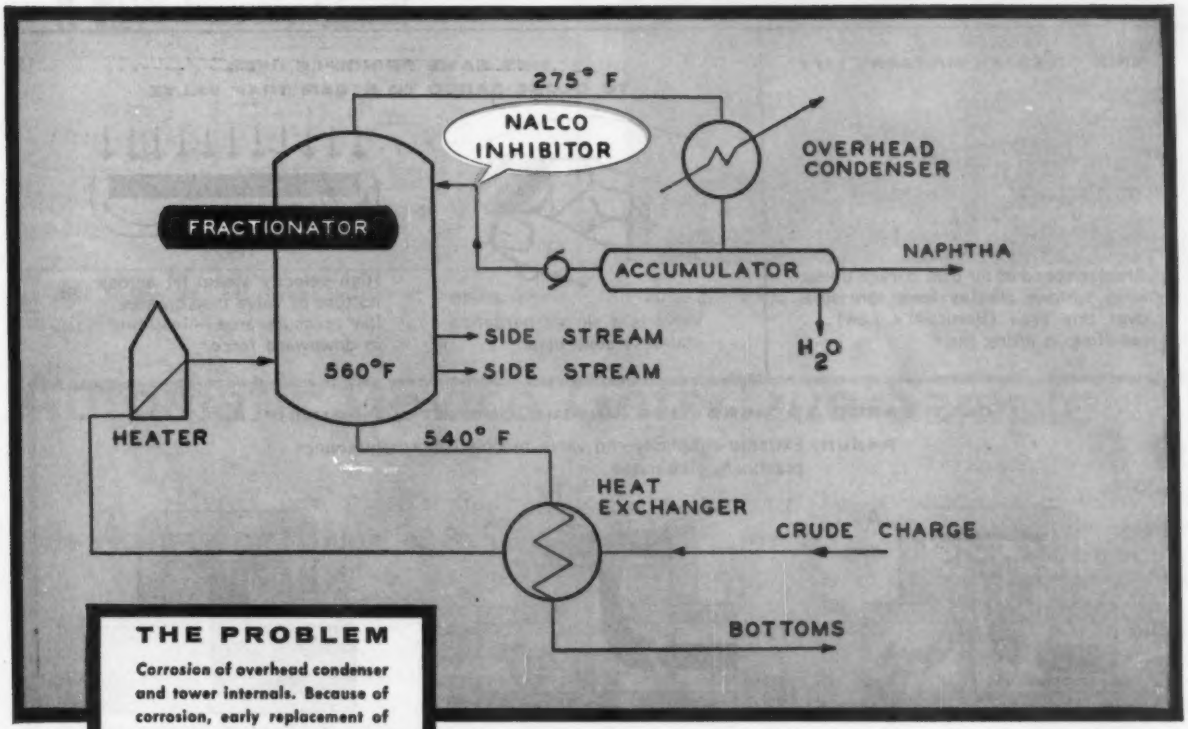
"Pilot Plants, Models and Scale-Up Methods in Chemical Engineering"

This book presents a study of the many ways in which model theory and emperical extensions of it can be used in the design of pilot plants and models, and in the interpretation and scaling up of experimental results.

The opening chapters deal exhaustively but clearly with similarity, dimensional analysis, the regime concept, similarity criteria, extrapolation, and other theoretical principles. Later chapters show how these principles are utilized in the scaling up of a wide variety of chemical engineering operations. The approach is analytical and quantitative, but with enough descriptive matter and worked examples to show how the principles are applied. The final chapter deals at length with the mathematical theory of analogue models.

(McGraw Hill Publishing Co., 330 West 42nd St., New York, N. Y. 307 pages, $9.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

HOW *nalco* INHIBITORS CUT DOWNTIME 74% ... AND SAVED THIS FRACTIONATING TOWER



THE PROBLEM

Corrosion of overhead condenser and tower internals. Because of corrosion, early replacement of the tower was contemplated.

THE TREATMENT

Nalco Corrosion and Fouling Inhibitor applied into overhead reflux.

THE RESULT

In this case only one point of application protected both fractionator and overhead equipment. Iron in accumulator water brought below 0.5 ppm as compared to previous 100-150 ppm. Corrosion and plugging stopped, tower saved, and downtime for cleaning reduced by 74%.

EFFECTIVE Nalco corrosion control is very low-cost protection. For example, this refinery not only avoided the cost of a new tower, but cleaner tower internals actually resulted in better fractionation and higher quality products. If you would like further facts on Nalco Corrosion and Fouling Inhibitors, ask your Nalco Representative or write direct.

NATIONAL ALUMINATE CORPORATION
6259 West 66th Place • Chicago 38, Illinois
Telephone: POrtsmouth 7-7240
CANADA: Alchem Limited, Burlington, Ontario
NORTHWESTERN UNITED STATES, HAWAII and ALASKA
The Flox Company, Inc., Minneapolis 3, Minnesota
ITALY: Nalco Italiana, S.p.A.
WEST GERMANY: Deutsche Nalco-Chemie GmbH
SPAIN: Nalco Espanola, S.A.

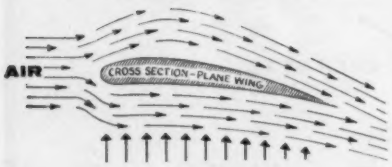
THE *nalco*® SYSTEM ... SERVING INDUSTRY THROUGH PRACTICAL APPLIED SCIENCE

For more data on advertised products, use Readers' Service Cards, last page.

HOW THIS MODERN STEAM TRAP UTILIZES PRINCIPLE OF AIRPLANE LIFT!

New application of an old principle produces totally different type of steam trap ... of great simplicity and effectiveness

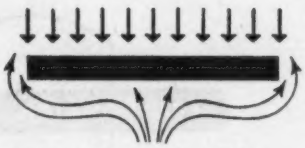
THIS GIVES AN AIRPLANE LIFT



Greater speed of air over curved upper wing surface creates lower pressure over this area (Bernoulli's Law) ... resulting in lifting force.

THIS SAME PRINCIPLE USED TO CLOSE SARCO TD STEAM TRAP VALVE

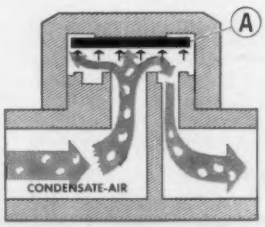
Valve is a simple hardened stainless steel disc.



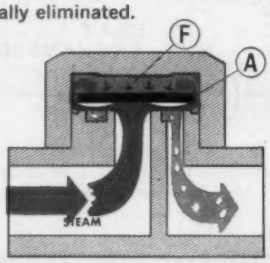
High velocity steam jet across bottom of valve disc creates low pressure area — resulting in **downward** force.

ONLY SARCO TD USES THIS UNIQUE OPERATING PRINCIPLE

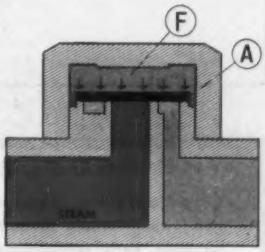
Result: Extreme simplicity—no valve mechanism—maintenance practically eliminated.



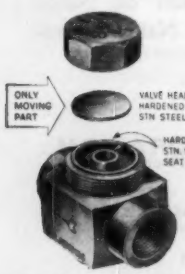
1. Inlet pressure raises disc "A" from seat ... immediate discharge of air and condensate at steam temperature.



2. Steam follows condensate and the high velocity jet across bottom of disc "A" creates low pressure area (Bernoulli effect) ... jet is deflected into chamber "F" where it builds up pressure by recompression and this pressure acts on top of disc "A" ...



3. Pressure in chamber "F", acting on full top area of disc "A", exceeds force of incoming steam and low pressure area under disc ... and immediately forces it down, closing inlet. As condensation decreases pressure in chamber "F", disc rises and steps 1 or 2 repeat.



Small size ... large capacity

Only 3 parts ... all stainless steel. Sizes ⅜ to 1"—each body is as small as a tee fitting! Capacity is determined not by a bulky body but by the effective orifice, valve action, pressure drop and condensate temperature.

A few of many advantages

* *Practically no maintenance*—no valve mechanism, no narrow channels. Trouble-free, simple design.

* *Cuts trap inventory*—one large capacity seat for all pressures ... for heavy, light, or no condensate load.

* *Self-adjusting for pressures 10 to 600 psi*—not a single change or adjustment required.

* *Operates perfectly when pressure fluctuates*—throughout full pressure range.

SEE FOR YOURSELF

We will gladly send you a Sarco TD Steam Trap and strainer for 60-day trial. No cost or obligation. Advise size —⅜, ½, ¾ or 1"—and application. Sarco Company, Inc., Empire State Bldg., New York City.

2204-C

SARCO Thermo-Dynamic STEAM TRAP

THE MODERN TRAP THAT IS MAKING STEAM TRAPPING HISTORY!

How To Do It . . .

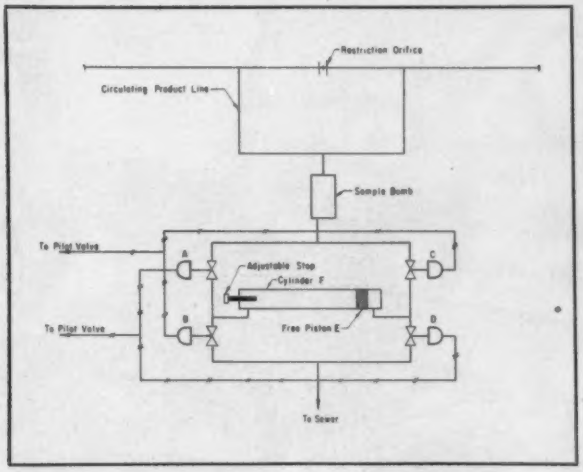


FIGURE 1—Diagram shows working principle of sampling device.

FIGURE 2—Working model uses chart motor as driver for cycle timer.

Automatic Device Gets True Sample

Here's one plant's method for obtaining a truly representative sample of its product.

The purpose of continuous process sampling is to obtain a truly representative sample. This is particularly true in the case of fluid processes. Where the volume of product being produced or used is a variable quantity, the sample is usually withdrawn continuously from the line with the rate of withdrawal proportional to the flow rate of the substance being sampled.

In many cases, proportional sampling is not required since the flow rate of the product is essentially constant. In this case, a simpler and cheaper device is used which withdraws a sample at a constant rate (Figure 1).

The sample is collected in a standard sample bomb by displacement of the liquid which is measured. The sampler is arranged so that a fixed volume of the liquid to be sampled is withdrawn at fixed intervals. The volume of the sample collected at each interval is controlled by altering the volume of liquid swept out by a free piston (E) in a cylinder (F). The piston is moved in the cylinder by line pressure which is applied alternately to each side of the piston by opening either valve A or valve C. The liquid is then swept out to sewer through either valve B or D. The disposed sample displaces the liquid in the sample bomb and draws a new, representative sample from the circulating system.

The valves are actuated by two, time-cycle controllers which set the intervals at which the sample is withdrawn. The controllers are arranged so that when A and D are open, C and B are shut and vice versa. Since the valves take a finite time to open and close, the cycle timer is also arranged so that A and D are shut *before* B and C open and so that B and C shut *before* A and D open. This is essential to satisfactory operation.

Initially, attempts were made to use a 4-way valve actuated by one, time-cycle controller. This, theoretically, would perform satisfactorily. Unfortunately, four-way valves were never very successful since they invariably began to leak slightly between the various openings after being in service a short while.

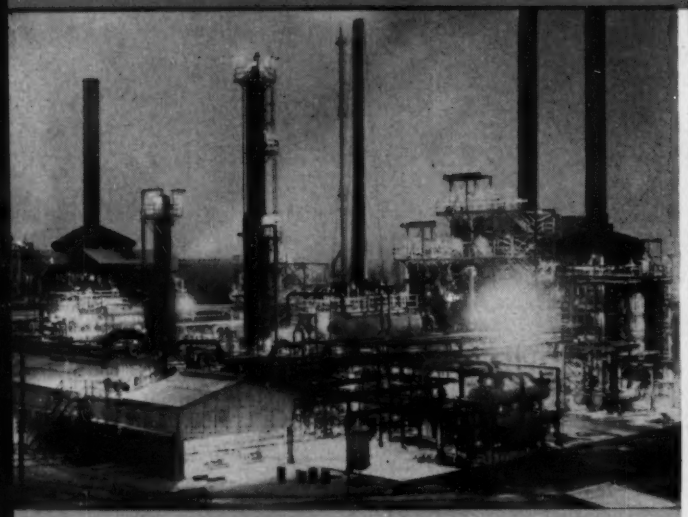
Four, on-off valves, two direct acting and two reverse acting, actuated by one time cycle controller were then tried. This was not successful because the valves required a finite time to operate. Consequently all four valves were open for a short time during the actuating period allowing the liquid from the bomb to bypass the cylinder and piston.

The successful device previously described and shown in Figure 2, was pneumatically actuated, the cycle timer itself being driven by a mechanical chart drive motor. This was done in order to overcome explosion-proofing problems. There is, however, no reason why in other circumstances the whole unit could not be electrically operated.

Automatic Operation. Two cams attached to the shaft of a mechanical clock which rotates once per hour. Each cam actuates a nozzle and flapper arrangement, the output of which is fed into a pilot valve or

124,500 B.S.D. of NEW CAPACITY

IN FOUR NEW PROCESSING UNITS BY McKEE AT WOOD RIVER, ILLINOIS



ON STREAM This new Platforming Unit recently went on stream with a 20,000 B. S. D. capacity. It was designed, constructed and completely equipped by McKee.

UNDER CONSTRUCTION This Catalytic Reformer designed and being constructed by McKee will add 7,500 B.S.D. to processing capacity in the Wood River area.

IN ENGINEERING A 67,000 B. S. D. Atmospheric-Vacuum Crude Disilltation Unit now on McKee drawing boards will be constructed by McKee at Wood River.

IN ENGINEERING A 30,000 B.S.D. Fluid Catalytic Cracking-Vapor Recovery Unit scheduled for Wood River is to be designed and constructed by McKee.

McKee
ENGINEERING & CONSTRUCTION
Services

EACH of these Wood River projects represents a repeat contract that was awarded to McKee by a satisfied customer who has had previous proof that *McKee builds plants that earn profits.*

Arthur G. McKee & Company • Engineers and Contractors
Headquarters: McKee Building • 2300 Chester Avenue • Cleveland 1, Ohio
Offices: New York, N. Y. • Union, New Jersey • Washington, D. C.
British Representatives of Metals Division: Head, Wrightson & Co., Limited
Canada: Arthur G. McKee & Company of Canada, Ltd., 372 Bay St., Toronto

pneumatic amplifier. The output from the pilot valve feeds the pneumatic control valves (A and D or B and C) which admit the liquid to the correct side of the piston. It should be emphasized that the two pneumatic systems are completely independent.

The sample volume which is obtained in any given period may be adjusted in three ways. Small variations may be obtained by altering the adjustable stop on the cylinder so that the piston travel is altered. This results in a different swept volume per stroke. Large variations may be obtained by either altering the cams so that each valve is operated more frequently per revolution or changing the rotation speed of the clock motor to produce the same effect.

How to Do It . . .

Costs. Excluding the sample bomb and the circulating system to bring the liquid to the sampler, the material required to build a pneumatic sampler of the type required, costs approximately $175. It can be built with approximately 50 hours labor.

Idea submitted by
G. M. Hicks and W. J. McKay
Polymer Corp., Ltd.
Sarnia, Canada

When It's Moving Time at Your Plant . . .

. . . roll your tanks Don't Slide Them!

The old method of moving a tank was to slide it along on bare rails which were resting on logs. The rigging crew at Esso's Bayonne refinery developed a new method that saves time and effort. The tank is jacked up and placed on dollies which roll along in a set of special, grooved rails. The photograph shows workmen removing wedges from one of the dollies in preparation for the big push.

Item courtesy of the *Esso Bayonne News*.

Seal Vacuum Inlet Wet Gas Compressors

Centrifugal gas compressors, feeding absorbers, are often operated at near atmospheric intake pressures. These compressors take "wet gas" from catalytic crackers, cokers or even crude distillation units and supply it to absorbers of vapor recovery (gas concentration units).

In some plants, the compressor intake pressure is always kept slightly above atmospheric, at the compressor inlet nozzle. In others, it may be throttled so that the compressor has a slight intake vacuum, most of the time. In still others, the compressor may actually vary the inlet pressure by its own action, both above and below atmospheric, particularly on constant speed compressors when the *discharge* pressure is maintained constant by other instrumentation. Note that in the latter case, as the molecular weight of the gas varies, and the head developed by the compressor remains substantially constant for a given set of impellers at a given speed, the differential pressure will vary, causing the inlet pressure to vary.

For the cases of varying compressor inlet pressure, the compressor manufacturer should prepare curves of intake pressure versus capacity, at constant discharge pressure and constant speed, for the normal, maximum, and minimum molecular weights anticipated. This will enable the manufacturer to estimate the probable lower limit of intake pressure in the

Here's proof

Superior quality forged body —precision machined
Uniform wall thickness —no weak spots
Extra heavy reinforcing rim
Larger diameter cam ears for longer service life
Extra Hi-Strength forged handles —greater economy
Stainless Steel pins —greater safety and longer service
Uniform heavy wall thickness —no weak spots
Recess retains gasket in coupler and assures proper placement
Superior quality forged body —precision machined —accurate tolerances

your best buy is EVER-TITE -the best quality quick couplings

Bronze
Aluminum
Stainless
Carbon
Malleable
Hastelloy

You save time and money when you use EVER-TITE COUPLINGS, because you get speedy deliveries—no leaks. The tightness is predetermined in manufacture so you can be *sure* with EVER-TITE.

The EVER-TITE trademark is a hallmark of dependability. EVER-TITES do the best job in the transfer of every type of product through hose or pipe.

Get EVER-TITE and get the *best*. Ask your distributor now.

EVER-TITE COUPLING CO. INC.
254 West 54th Street
New York 19, N. Y.

Dust Plug

Dust Cap
EVER-TITE Dust Protectors

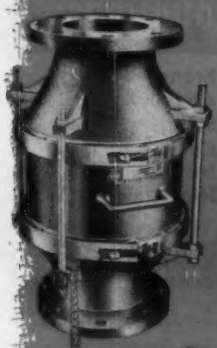
Every EVER-TITE saves time and money

For more data on advertised products, use Readers' Service Cards, last page.

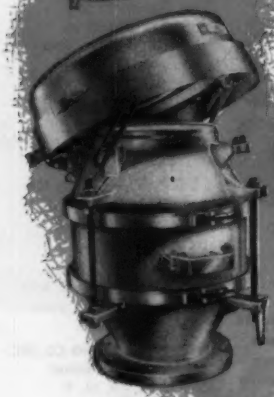
For Maximum Protection of Volatile Liquids in Storage

. . . Equip Your Tanks With BS&B *Lightweight* Tank Vents and Flame Arrestors!

The BS&B Tank Vent, Type 76-16, features a floating seal for positive shut-off under both pressure and vacuum. Positive seal is effected without utilizing the weight of the hinged cover. Vapor pressure within the tank (or atmospheric pressure in the case of vacuum) maintains seal. Cover and major internal components are aluminum with stainless or plated steel hardware; plastic coated bases are cast iron. These vents mount to 125 lb. ASA bolting circles in sizes 6″ through 12″.



BS&B Flame Arrestors, Type 76-18, for free vent systems, may be mounted either horizontally or vertically. End connections are 125 lb. ASA flanged for mounting to open vent lines of process vessels. Flame bank end flanges are identical to those of the Type 76-17 Arrestor Vent Bases (below). Lightweight, maximum venting capacity and servicing ease are important features of the Flame Arrestor.



BS&B Arrestor Vent, Type 76-17, combines the features of Types 76-16 and 76-18 described above. It functions both as a tank breather and as a cartridge type flame arrestor to prevent ignited vapors from flashing back into the tank. Flame bank is secured by two quick opening V-clamps for easy access to unit for inspection or servicing. Normal venting with the flame bank removed is maintained by simply securing the top unit to the base with one V-clamp. Internals of flame bank are alternate layers of flat and corrugated aluminum strips, in a continuous roll.

Ask your BS&B Representative for Catalog 76-16 or write direct to . . .

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vacuum region, except for start-ups. However, during the acceleration of a motor driven unit, if the inlet to the compressor is throttled too much, even greater vacuums (lower absolute pressures) will be reached.

When these curves have been prepared and the question of inlet throttling during acceleration has been faced, attention can be drawn to the sealing system in order that it can be made suitable for the full range of intake pressures to which the machine may be subjected.

The sealing of all these near-atmospheric-inlet wet gas compressors can be done in several ways:

- Sweet gas injection (sweet, dry and clean), to labyrinths.
- Ejectors, steam actuated, from labyrinths.
- Ejectors, wet gas actuated, from labyrinths.
- Sleeve or bushing type oil seals, with manual control of oil pressures.
- Sleeve or bushing type oil seals, with automatic regulation of the oil pressures.
- Contact or face type oil seals.
- Dry type contact seals.

Sealing arrangements that are satisfactory for compressors always having a slight positive inlet pressure are not necessarily suitable for both positive and negative inlet pressures. At least two manufacturers avoid some of the difficulties on motor driven machines by taking a small gas sidestream from the discharge of the compressor through a regulator and feed it to a mid-point (or near the inside) of the labyrinths at the two ends of the compressor. Thus, it is possible to achieve a slight positive pressure for the seals or outer labyrinths of the compressor even though the inlet pressure is temporarily or continuously in the vacuum region.

It should not be assumed that oil seals, known to be satisfactory for other gas compressors having very high inlet pressures, necessarily provide the best type of sealing arrangement for a near-atmospheric inlet machine. The state of the art has not yet shown a clear indication of any one best sealing arrangement. It can be said that sealing of refinery wet gas compressors is apt to be difficult and deceiving, often more so than the sealing of compressors having very high inlet pressures.

DU PONT

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PETROLEUM ENGINEERING NEWS

LATEST PROPERTY AND APPLICATION DATA ON

TEFLON® tetrafluoroethylene resins

New heat- and acid-resistant seals of TEFLON® tetrafluoroethylene resins check high pressures in oil-well tubular joints

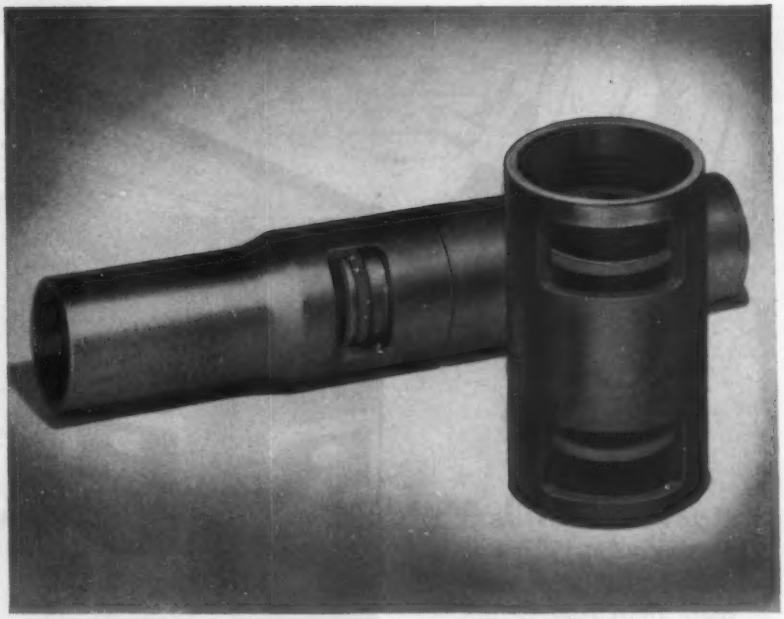
Even the ultra-high pressures in Gulf Coast oil and gas wells are tamed by seals of TEFLON resins. The Hardy-Griffin Engineering Corporation uses such seals as the basis for its new joint and coupling designs for well tubing and casings.

Some of the test results have been eye openers to oilmen. The seals pass hydrostatic tests to 17,500 psi without trouble. They develop no leakage in tests which subject them to 100 cycles of thermal shock and gas pressurization between 95° and 180°F. and 13,000-15,000 psi. The tests greatly accelerate the effects of alternate well flow and shut-in.

TEFLON tetrafluoroethylene resins are rated for continuous use up to 500°F. They are inert to virtually any chemical encountered in oil extraction and refining, in petrochemical processing or in commercial practice. The few exceptions to this include attack by the alkali metals under certain conditions. At high temperatures and pressures, halogens and certain halogenated chemicals and solvents may also affect TEFLON resins. TEFLON resins are prized for fabricating seals, gaskets, packings and bearings due to their toughness, flexibility, low surface friction and limited cold flow.

The cold-flow properties of TEFLON resins give Hardy-Griffin sealed joints ability to seal tightly. The sealed joints can be re-used under the most difficult conditions. Used API couplings, when modified to GT-API specifications with seal rings of these resins installed, are restored to like-new performance.

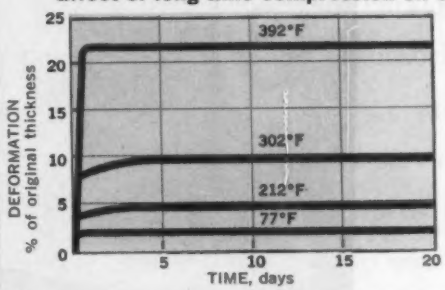
Many engineers in the chemical and mechanical phases of the oil industry have benefited by knowing the complete story about TEFLON tetrafluoroethylene resins. We'd like to show you how others have solved design and maintenance problems with Du Pont TEFLON resins. Send the coupon for a mailed reply.



RING SEALS made of TEFLON tetrafluoroethylene resins prevent leakage at pipe joints in wells developing high pressures and for mild low pressure. Seals are extremely resistant to acids and heat. Front – GT-API sealed coupling. Background – mating HGT "Super-Slim" integral sealed tubing joint. Cutaway sections reveal position of seals. (Manufactured by Hardy-Griffin Engineering Corporation, Houston, Texas.)

Effect of long-time compression on solid TEFLON®, 1,000 psi

tetrafluoroethylene resin



Curves show deformation of a seal made of a TEFLON tetrafluoroethylene resin as a function of time and temperature. Tendency to cold flow is not excessive and occurs only during first few hours after load is applied. Equilibrium is rapidly reached and no further change occurs unless load or temperature change. TEFLON has good recovery after deformation, permitting re-use of seals.

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SEND FOR INFORMATION

For additional property and application data on Du Pont TEFLON tetrafluoroethylene resins, mail this coupon.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept. Room 368, Du Pont Building, Wilmington 98, Delaware

Please send me more information on Du Pont TEFLON tetrafluoroethylene resins. I am interested in evaluating this material for_____

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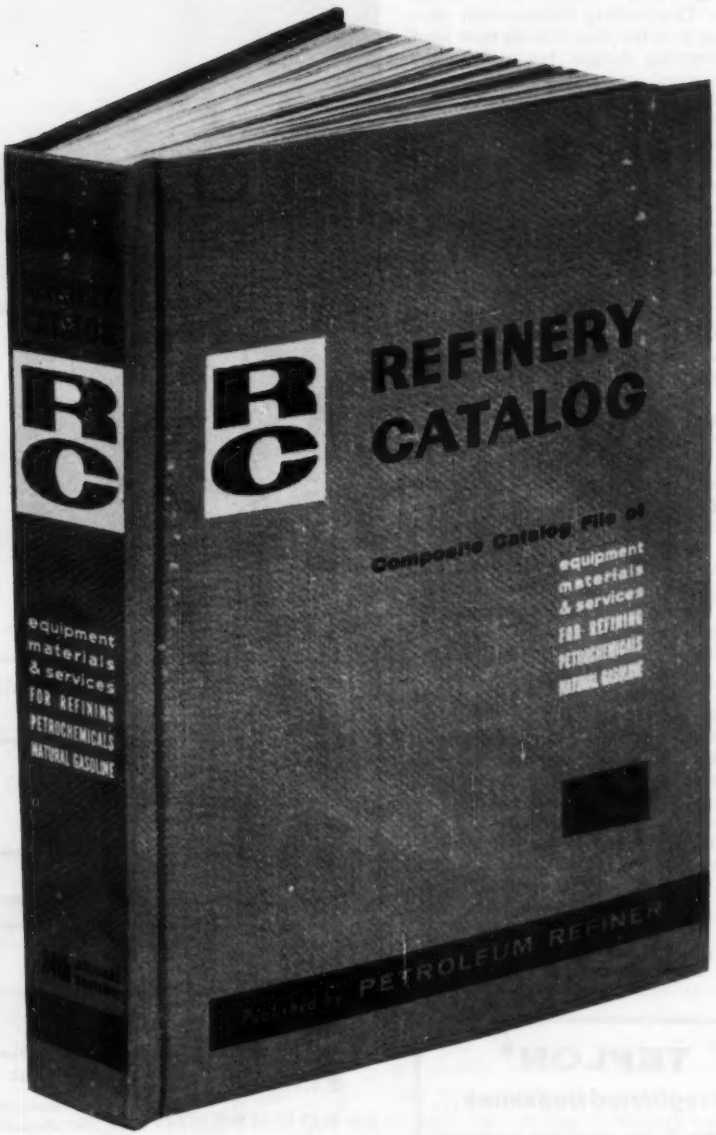

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Who's Building . . .

Construction BOXSCORE appears next in October

Surpass On Stream with Sulfonates

First Canadian plant for this purpose will produce about 7 million pounds per year.

The first Canadian chemical processing plant for the production of petroleum sulphonates has been placed in operation by Surpass Petrochemicals Ltd., Scarborough, Ontario, Canada. Built at a cost of $750,000, the new plant will produce 7 million pounds per year of oil-soluble sodium sulphonates such as those containing lithium, calcium, barium, ammonium or amine.

The plant was designed and engineered by The Girdler Co., a division of National Cylinder Gas Company. The primary sulphonation reaction takes place in a multiport injection reactor, a specialized heat exchange unit. Primary sulphonation, sludge separation, neutralization and stripping are continuous while the remaining steps are batch operations.

A set of proportioning pumps deliver oleum and a special cut of petroleum crude to the first reactor. The reactor is water-jacketed to keep the temperature of the primary sulphonation reaction constant and to remove heat given off by the reaction.

Water and naphtha are added to the "sour oil" or crude sulphonate as it passes from the reactor into the sludge separation tank. The sludge is drawn off to waste and the "sour oil" is drawn off at the correct level to be pumped to the second reactor where, with caustic soda, the neutralization takes place.

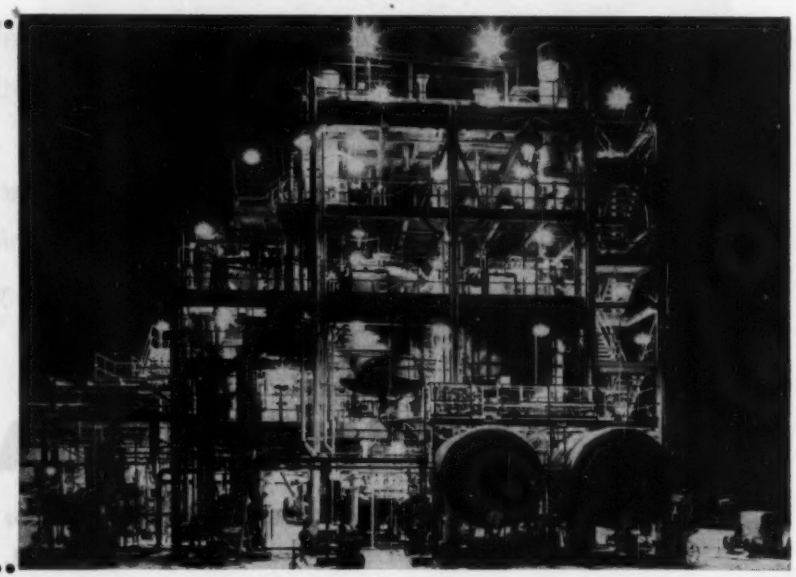
Brine is separated from neutral oil in the next tank. Brine is discarded and the oil enters the top of a steam naphtha stripper. As the steam rises, it carries the naphtha with it. Water and naphtha are separated in a decanter, and the naphtha goes to storage. The neutral oil passes out the bottom of the stripper into a surge tank. This is the end of the continuous part of the process. The last steps are carried out in batches.

To the neutral oil in the classification tank at the start of the batch operation is added secondary butyl alcohol and salt solution. After thorough mixing, the solution is allowed to settle. Three distinct liquid phases result. The bottom or brine layer containing inorganic salts and low molecular weight organic impurities is transferred to a still for alcohol recovery. Concentrated sodium sulphonate is recovered as the main product from the second layer by removing alcohol and water in a second still. This goes either directly into drums or to storage in the tank farm. The top layer from the classification tank goes to a third still where unreacted oil is separated from SBA and water.

All the vessels are mild steel except the reactors which are stainless steel. Most of the vessels operate at atmos-

Night Scene . . .

. . . at du Pont's new 15 million pound capacity synthetic rubber plant which recently went into production at Beaumont, Texas. Known chemically as chlorosulfonated polyethylene, the du Pont product is a special purpose rubber which resists ozone and oxidation, the two main enemies of other elastomers. Until the new plant went on stream, the synthetic rubber was manufactured on a limited scale at the company's Belle Works near Charleston, W. Va.



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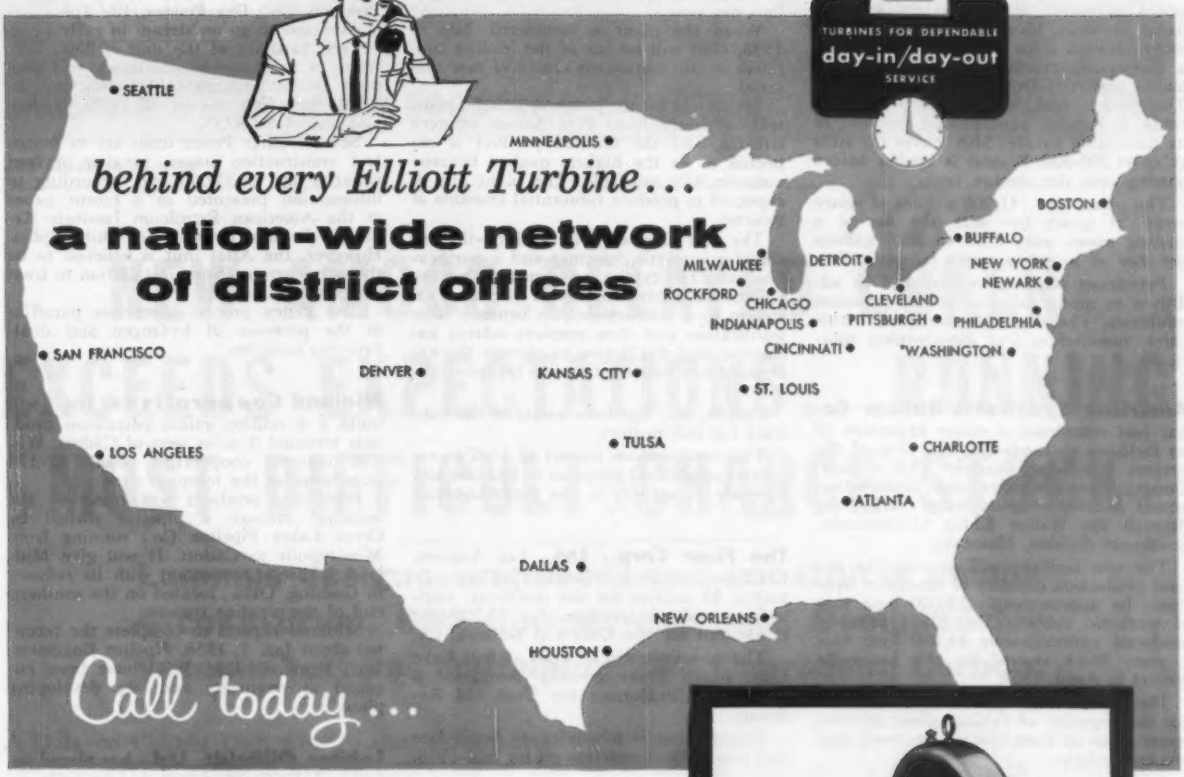

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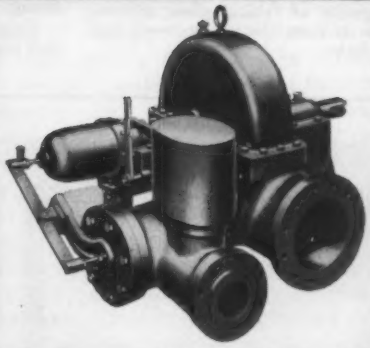

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Who's Building...

phere pressure. Safety devices such as flame arresters, blow-off valves and interlocks between steps are used. In addition, a three-compartment trap prevents flammable materials from entering the sewer. The storage tank for secondary butyl alcohol is located underground because of its flammable nature. SBA leaves the stills at over 200-300 F. and is cooled before passing into the storage tank.

The plant uses 141,000 gallons of water every 24 hours but with the use of a cooling tower, only 2500 to 3000 gallons per day of make-up water is required.

Petroleum sulphonates are used as additives to motor lubrication oil, corrosion inhibitors, chemical intermediates, herbicides, insecticides and dry-cleaning solutions.

American Synthetic Rubber Co. has just completed a major expansion of its facilities at Louisville, Ky. Cost of the project was approximately $3.5 million. Design, procurement and construction phases of the program were carried out through the Walter Kidde Constructors, Southwest division, Houston.

The new facilities will increase the annual production capacity of American Synthetic by approximately 25,000 long tons of synthetic rubber. The plant formerly produced approximately 44,000 long tons a year. Work started on the Louisville project in April, 1956.

The expansion project included increasing the capacity of critical plant utilities, construction of new reactor, recovery and process facilities.

Gulf Oil Corp. will enter the field of benzene production with construction to begin this summer of a large benzene plant at its Port Arthur, Texas, refinery, capable of producing approximately 30 million gallons per year.

When the plant is completed, late in 1958, Gulf will be one of the leading suppliers of this important chemical raw material.

Feedstocks for the planned benzene plant will be drawn from Port Arthur refinery streams, and the finished product is expected to be the highest quality benzene commercially available. The plant also is expected to produce substantial amounts of toluene.

The new plant at Port Arthur will consist of a catalytic reformer and a purification unit. The catalytic reformer will utilize a platinum catalyst to convert a hexane-rich stream to a mixture rich in benzene. The purification unit then employs solvent extraction and distillation to recover the extremely pure benzene from the benzene mixture.

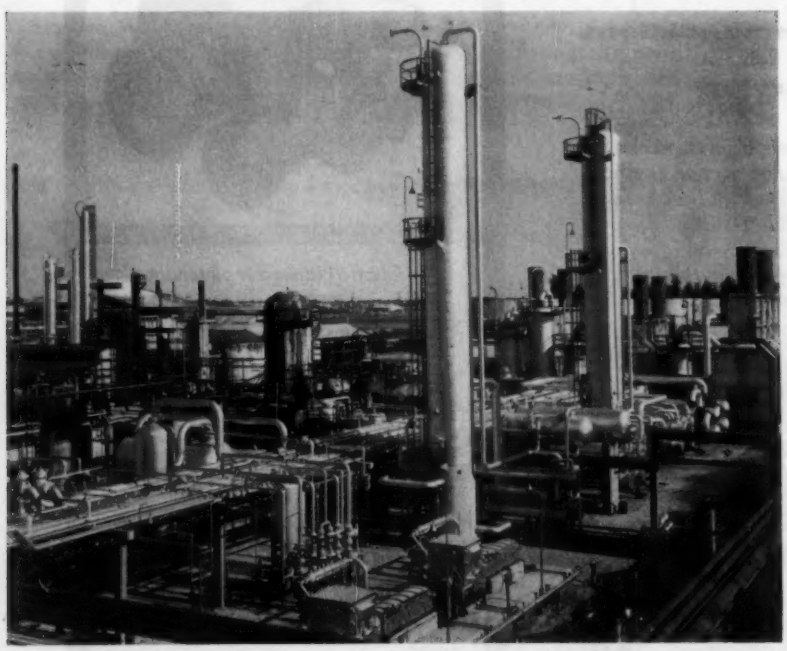
Procon, Inc. has been awarded the contract for this project.

The new venture is part of Gulf's previously announced program to increase and diversify its activity in the petrochemicals field.

The Fluor Corp., Ltd., Los Angeles, has been awarded a contract of approximately $2 million for the designing, engineering and construction of a 35,000-bpd crude unit for the Utah Oil Refining Co.

The new unit will be built at Salt Lake City, where Fluor recently completed a 5500-bpd Ultraformer for Utah Oil Refining.

Construction is scheduled to begin late this year with completion set for mid-1958.



New Wilshire Units

Pictured is the new 10,000 bpd Platformer-Unifiner units which were recently placed on stream at the Norwalk, Calif., refinery of Wilshire Oil Company of California.

Atlas Processing Co. has begun construction at Shreveport, La., of the first commercial hexane isomerization unit. The unit will utilize the new Penex hydroisomerization process licensed by Universal Oil Products Co., Des Plaines, Ill. The plant is expected to go on stream in early 1958.

Feed capacity of the unit is 3500 bpd. Atlas, a processor of distillates, will produce several streams of blending components, including one of 98 RON, leaded, and one of 90 RON.

Several other Penex units are in design and construction stages, ranging in feed capacity up to 35,000 bpd, according to information presented in a recent paper at the American Petroleum Institute Refining division meeting in Philadelphia. However, the Atlas unit is believed to be the only current Penex installation to treat n-hexane exclusively.

The Penex process isomerizes paraffins in the presence of hydrogen and dual-function catalysts.

Midland Cooperatives, Inc., will build a 6 million gallon petroleum products terminal 3 miles west of Cadott, Wis. The regional cooperative bought a 170 acre farm for the terminal site.

Petroleum products will move to the terminal through a pipeline owned by Great Lakes Pipeline Co., running from Minneapolis to Cadott. It will give Midland a direct connection with its refinery in Cushing, Okla., located on the southern end of the pipeline system.

Midland expects to complete the terminal about Jan. 1, 1958. Pipeline Engineers, Inc., Fond du Lac, Wis., have been engaged as engineers and are developing plans.

Lobitos Oilfields, Ltd., has placed an 800-bpd UOP Platforming unit built by Procon (Great Britain) Ltd. on stream at its Ellesmire, Cheshire refinery.

The unit is designed to produce an 85 to 90 RON clear product from Kuwait naphtha or a 90 to 95 RON clear blending component from mixed Peruvian naphthas.

Included in the construction project is a prefactionator to separate naphtha from full-range gasoline or prepare a 127-302 F. naphtha for Platforming feed from Peruvian stock. Other equipment built by Procon during erection of the Platforming unit includes amine recycle gas scrubbing facilities with water wash and glycol drying for use when processing a Kuwait charge.

Fluor Products Co., division of The Fluor Corp., has completed new facilities near Santa Rora, Calif., for pre-fabrication of cooling tower components made of redwood, which is available in the area. Office building, as well as other administrative structures, were built by Younger Construction Co., San Francisco general contractors.

Standard Oil Co. (Indiana) will build additional laboratory facilities for research work on solid rocket propellants for the United States Air Force at Freeman Field, Seymour, Ind.

Standard Oil Company scientists and research personnel at Whiting, Ind., and Seymour have been active in development of solid rocket propellants since 1951. In 1954 the first facilities for this work were constructed by the company at Seymour in cooperation with the Wright Air De-

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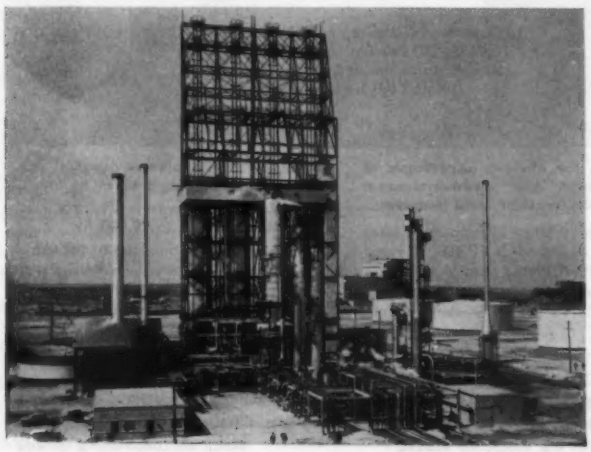
NEW AMOCO DELAYED COKER EXCEEDS EXPECTATIONS...RUNNING MOST DIFFICULT CHARGE STOCK

Lummus designs, engineers and constructs unique 4-coke-drum, 600 ton-per-day unit. Designed for vacuum bottoms containing 25% Conradson Carbon.

A Delayed Coking Unit which handles the heaviest feed ever charged is now in operation at the new Yorktown, Virginia refinery of The American Oil Company.

The unit has been in continuous operation since the initial firing on January 30, 1957, surpassing all guarantees of capacity of charge stock and product specifications, and has been formally accepted before completion of this run.

The fractionating tower produces light and heavy gasoline and light and heavy gas oils meeting all rigid Amoco specifications for the production of high octane unleaded gasoline. Coke produced meets client's specifications for pulverizing for use in boilers.



This delayed coker at Amoco's new Yorktown, Va. refinery handles the heaviest charge on record. Four coke drums measure 17'6" x 75' tangent to tangent. Refinery will help supply unleaded "Amoco-Gas" to an 18-state market.

Evaluation of charge stock in Lummus laboratories and pilot plants supplied the information for special design features that were incorporated into the heater—the heart of the process—and other critical equipment, to handle the heaviest charge stock on record. The unit was designed for a charge mixture of vacuum reduced crude with 25% Conradson Carbon, an API gravity of 6.1°, and an SFS viscosity of 6,000 at 210° F. It was also designed to process a variety of stocks at different recycle ratios to meet required flexibility.

The new unit, based on pilot plant work at Lummus laboratories, was designed, engineered and built by The Lummus Company, and was completed 10½ months after the piles were driven.

Lummus has designed much of America's coking capacity — 10 units — combined capacity of over 120,000 barrels per day.

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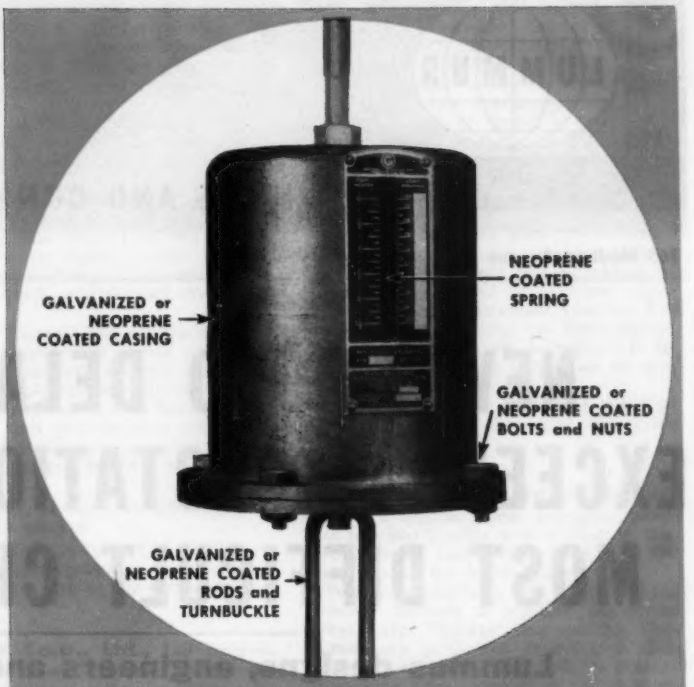
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Another Grinnell First!

Grinnell pre-engineered spring hangers are now offered in two new lines to meet the need for spring hangers in installations subject to highly corrosive industrial conditions and to severe weather exposure.

These hangers are the result of extensive experimentation with various coatings for Grinnell's standard pre-engineered spring hangers. In addition to providing flexibility in pipe suspension, they provide versatility of application through their corrosion-resistant characteristics. They are . . .

1. Neoprene coated—for highly corrosive conditions such as those found in chemical plants and refineries. *All* parts of the hanger are neoprene coated to protect the base metal from a wide range of corrosives. The flex life of the spring is unaffected by the neoprene . . . the coating resists cracking or flaking over a wide temperature range.

2. Galvanized—for outdoor installations where weather conditions are severe. All parts of the hanger are galvanized except the spring, which is neoprene coated to avoid alteration of temper, hydrogen embrittlement and decreased flex-life of the spring—usual hazards to springs from the galvanizing process.

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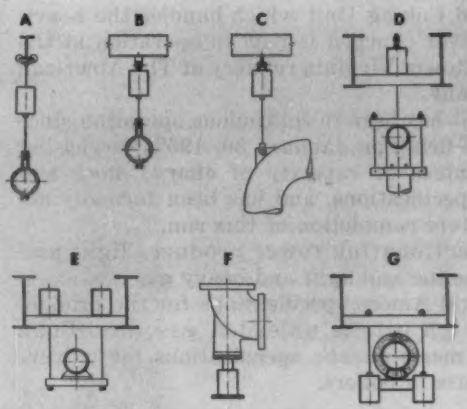

(A) Rod threaded to top cap (B) Furnished with single lug (C) Two lug style (D) Top adjusting (E) Adjustable top and bottom (F) For floor support (G) Trapeze assembly.

Along with the obvious advantages of such corrosion and weather-resistant characteristics, consider these features . . .

- Maximum variation in supporting force per ½" of deflection is 10½% of rated capacity—in all sizes.
- Precompression* assures operation of spring within its proper working range, as well as saving valuable erection time. Reduced over-all height saves space.
- 18 sizes available from stock for load ranges from 53 lbs. to 12,000 lbs.
- Available in 3 spring lengths for travel ranges of 1¼, 2½, and 5 inches.
- Installation is simplified by integral load scale and travel indicators.

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Who's Building...

velopment Center, Air Research and Development Command.

A separate plant, financed by the company, will be built at Seymour by Amoco Chemicals Corp., a subsidiary of Standard Oil Co. This plant, which was announced previously, will make jet aircraft engine starter cartridges.

Delhi-Taylor Oil Corp. formally entered the chemical market last month when the company's petrochemical plant at Corpus Christi, Texas went on stream. The new plant, a combination UOP Platformer-Udex unit equipped with the latest process control systems, was constructed by The Refinery Engineering Company. It will produce 45 million gallons annually of high purity benzene, toluene and xylene for the plastics, paint, pharmaceutical and other chemical process industries. The plant has its own docking facilities and is located for bulk shipments by barge, tank car or truck.

Caltex Petroleum Maatschappij has placed on stream at its refinery Pernis, The Netherlands, a UOP Platforming unit and two UOP Unifining units.

The 7500-bpd Platforming unit is producing high-octane gasoline from Arabian stocks. One of the Unifining units, with a capacity of 7500-pbd is designed to treat either Arabian straight-run naptha or a blend of straight-run and thermally-cracked naphthas.

The other Unifining unit, erected to remove sulfur and other impurities from diesel fuel, is designed to operate on a 4500-bpd charge of either virgin gas oil or a blend of virgin gas-oil and catalytically or themally cracked gas-oil.

Completion of the new facilities gives the Caltex refinery the first Universal Oil Products Co. designed Platforming and Unifining facilities in The Netherlands.

Continental Oil Co. has completed a $1.75 million natural gasoline plant in the Short Junction oil field south of Oklahoma City. The plant, which has a capacity of 60 million cubic feet daily, was constructed on Conoco's Nellie Fry lease in Cleveland county, four miles south of Oklahoma City's Will Rogers Municipal Airport and eight miles west of Moore.

The first natural gasoline installation in the Short Junction field, the plant will employ approximately 16 persons and will produce propane and butane, in addition to natural gasoline.

Turkish government has given permission for a new refinery to be built in that country. The exact location will be decided before the end of 1957 by a group of international oil companies. The companies are Mobil Overseas Oil Co., Inc., California Texas Corp., The British Petroleum Co., and Royal Dutch Shell. Capacity of the new refinery will be 65,000 barrels daily when it goes on stream, according to present schedules in 1960.

A crude distillation unit to process Turkish and other Middle Eastern crudes, and a catalytic reforming unit for upgrading naphtha, will be among the initial units. Automotive gasoline, kerosine, diesel and heavy fuel oil will be produced to satisfy indigenous product needs.

Cost of the new plant is estimated at $48 million, of which $13.5 million is to

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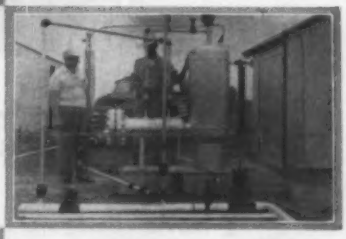

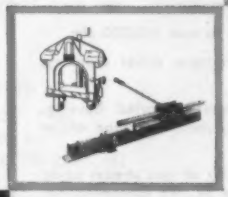

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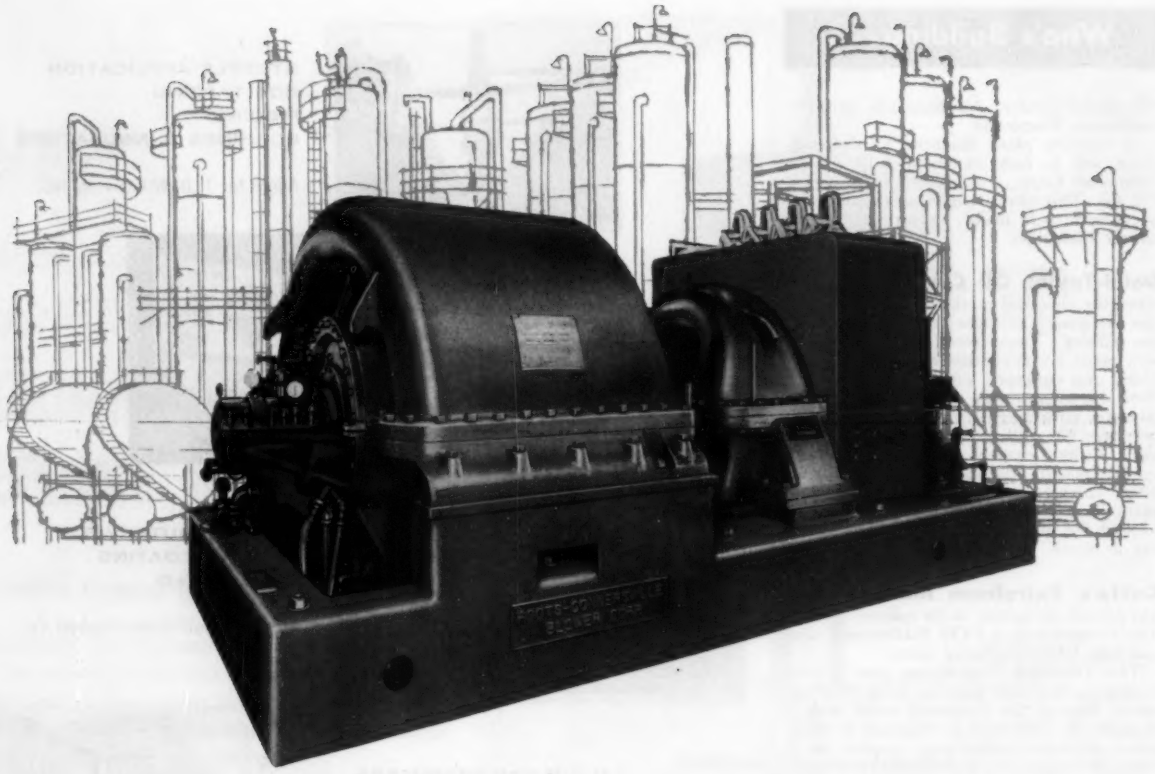

A DOZEN REASONS

why ROOTS-CONNERSVILLE centrifugal compressors are superior for refining applications

1. **PROVED** — industry-wide installations.
2. **TEN FRAME SIZES** — 2,000 to over 100,000 cfm.
3. **DRIVE-THROUGH** — for maximum driver economy, simplified installation.
4. **EXTERNAL BEARINGS** — case supported housing. Saddle type, semi-rigid supports. Precision alignment built-in.
5. **OIL FREE AIR OR GAS** — air or gas stream never comes in contact with lube oil. No contamination.
6. **DIRTY GASES EASILY HANDLED** — R-C units are not fussy about a little entrained dirt. Casing drains permit quick wash-down.
7. **EXTRA-RUGGED CASE** — maximum resistance to pressure. Freedom from alignment problems.
8. **UP OR DOWN CONNECTIONS** — available on all cases. Allows greatest piping freedom and economy.
9. **CENTER LINE CASE SUPPORT** — simple to install, no support problems with down connected machines.
10. **FACTORY PACKAGED AND TESTED** — compressors tested with their own driver, R-C has a modern steam plant for test purposes.
11. **PROVED SEALS** — interstage and shaft seals to fit the application.
12. **SIMPLE TO MAINTAIN** — accessible external shaft bearings and double thrust bearing. Easy to inspect rotor and internal seals. Cases split at the horizontal center line.

Unqualified mechanical dependability which assures continuous performance on the job under difficult operating conditions are inherent characteristics of Roots-Connersville centrifugals. They are the ideal choice when down-time cannot be tolerated.

Experienced Roots-Connersville engineers stand ready to tailor a multi-stage or single stage centrifugal compressor to your application. You can count on faster delivery too, due to a major expansion in manufacturing facilities. So, call in your nearest Roots representative who will gladly give you all the facts. Or write for Bulletin 120-B-14.

Engineers—unusual career opportunities await you at Roots-Connersville. Address your resume to Professional Employment Manager.

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Who's Building...

be spent in Turkey. The four participating companies will form a jointly owned company to operate the new plant, in which they will have the following respective interests: Mobil, 37 percent; Caltex, 34; Shell, 18, and BP, 11 percent.

It is felt that the new refinery, together with the Government's Batman refinery, now in operation will be able to satisfy domestic petroleum product demands. Should domestic crude production increase enough to make imports of crude unnecessary, the new plant will process Turkish crude only.

Kansas-Nebraska Gas Co., Phillipsburg, Kans., has slated a million dollar natural gas plant for Big Springs field in Southwestern Nebraska. The plant will process 35 MMcf of gas daily, and will turn out 25,000 gallons of propane, 8000 gallons of butane, and 6000 gallons of natural gas daily. The plant site will be at the firm's Big Springs compressor station.

City Products Corp. has completed a $1.5 million expansion at the Longview, Texas refinery of its wholly-owned subsidiary, Premier Oil Refining Co. The program involved improvements to existing facilities, and construction of a Platformer and a Unifier for upgrading gasoline.

Hercules Powder Co.'s 30 million pound a year polyethylene plant at Parlin, N. J., is now ready for commercial production. It will be the first plant in the U. S. to use the Zeigler process to produce the plastic. The Parlin plant will use ethylene from Esso Standard Oil Co.'s refinery at Linden for its raw material.

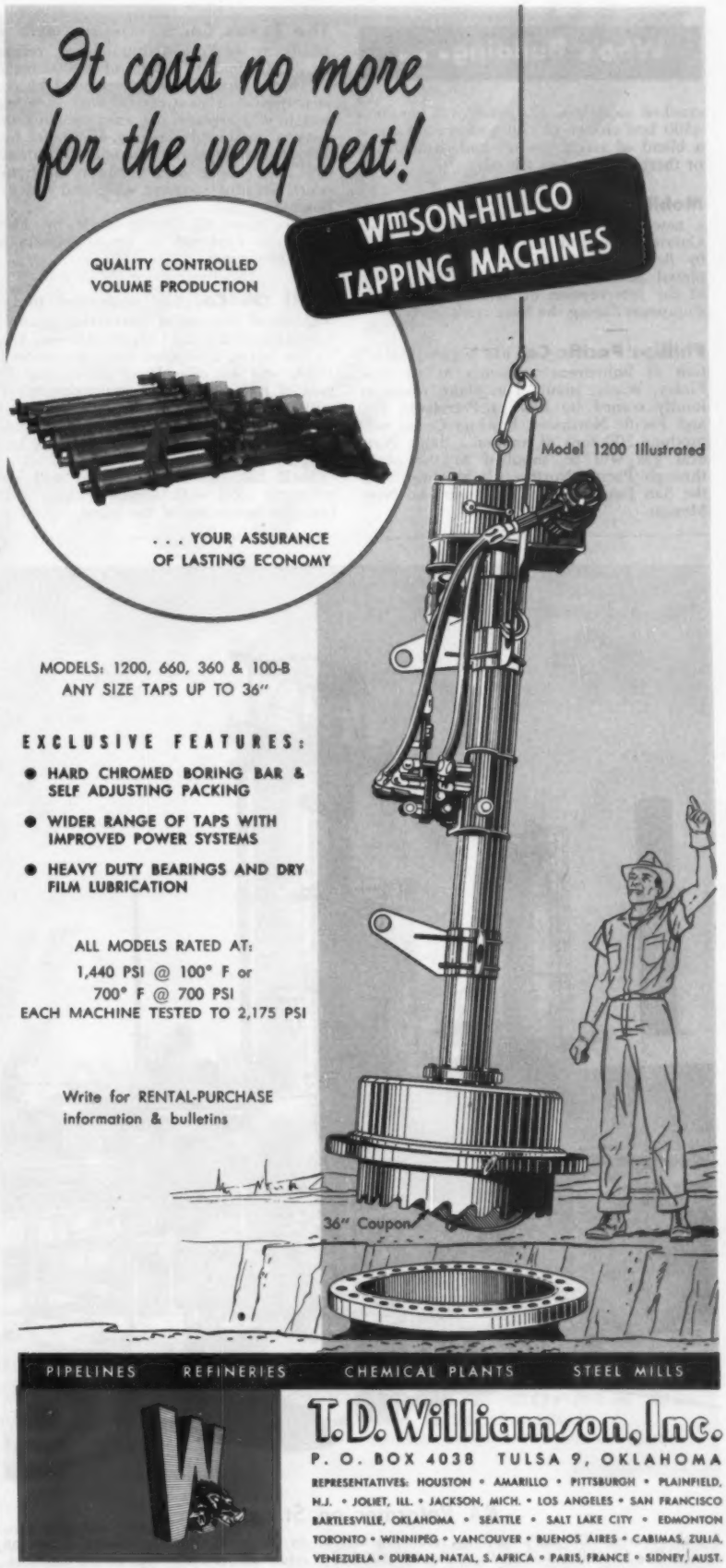
The Ziegler process polymerizes ethylene at substantially atmospheric pressure with a catalyst in liquid, producing a slurry of suspensoid. The polymer is then separated from the suspending agent, as a particle-size solid, then purified and dried.

Unity Petroleum Corp.'s 1200 bpd refinery at Kalispell, Mont., will be reactivated to produce jet fuel under an Air Force contract. Willard Aronow, president, said 700 to 1000 bpd of crude oil will be processed daily. Reduced freight rates granted the refinery enabled it to get back into operation.

Scientific Design Co., Inc., New York, has announced the completion of a new plant in northern New Jersey, especially designed and equipped for the production, on a commercial scale, of catalysts for processes developed by SD. Initially, the plant will make silver catalyst for SD's ethylene oxide process.

At the same time it was announced that SD will furnish catalyst for the new General Aniline & Film Corp. plant at Linden, N. J. now being erected by SD Plants, Inc. Eventually, catalysts for other SD processes and custom catalysts will be made. The plant was designed by SD and was constructed by SD Plants, Inc.

Caltex has placed on stream three new units at its Pernis refinery in The Netherlands. The 7500 bpd UOP Platforming unit is producing high octane gasoline from Arabian crude. One of the two new UOP Unifining units, with a 7500 bpd capacity, will treat either Arabian straightrun naphtha or a blend of straightrun and thermally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For more data on advertised products, use Readers' Service Cards, last page.

Who's Building...

cracked naphthas. The other will handle a 4500 bpd charge of either virgin gas oil or a blend of virgin gas oil and catalytically or thermally cracked gas oil.

Mobil Oil Co. has just placed on stream, a new 6000 bpd catalytic reformer at its Coryton, England refinery. The unit, built by Bechtel International, Ltd., was completed last fall but remained idle because of the interruption of Middle East crude shipments during the Suez crisis.

Phillips Pacific Co. has begun production of anhydrous ammonia at its new Finley, Wash., plant. The plant, which is jointly owned by Phillips Petroleum Co. and Pacific Northwest Pipeline Corp., will produce 200 tons of ammonia daily. Natural gas will be supplied to the plant through Pacific Northwest's pipeline from the San Juan Basin of Colorado and New Mexico.

The Texas Co. is increasing crude capacity at its Port Arthur, Texas, refinery by 20,000 bpd, to a total of 80,000 bpd.

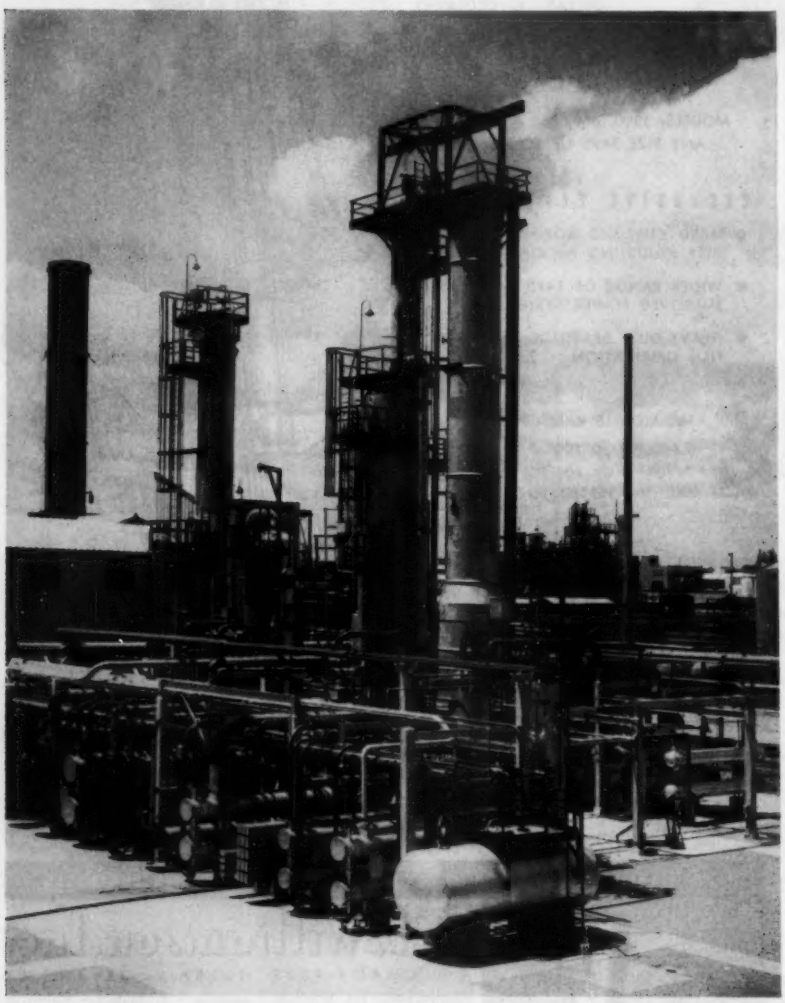
The capacity is being increased by construction of a new 80,000 bpd pipe still, which will replace the existing stills that have a combined capacity of 60,000 bpd. Major sections of the new still are a desalting unit, crude and vacuum distillation units, a sulfur recovery unit, and a decarbonization unit.

The new still, being built by Fluor Corp., is expected to be on stream by early next year.

Shell Oil Co. has announced that it will build the sulfur extraction plant it has planned for the Calgary Alberta, area.

The plant, scheduled for completion in 1958, will be capable of producing 300 tons of sulfur daily and approximately 15 million cubic feet per day of residue gas for sale in the Calgary area. It will process gas from the Okotoks gas fields, near Calgary.

Shell has announced that it will sign contracts soon with Devon Palmer Oils, Ltd., for operation of the plant.



BA Reformer on Stream

British American Oil Co.'s catalytic reforming unit at its Clarkson, Ontario, refinery is now on stream. The $4 million unit produces about 10,000 bpd of reformate for use in high octane gasolines.

The Lummus Co. has unveiled new engineering-development facilities, to bridge the gap from laboratory bench to full scale plants for the chemical and petroleum industries.

"The trend is toward larger, more complex production facilities for these industries," according to J. F. Thornton, Lummus president. "Engineering development can spell the difference between a rash gamble and a sound plant investment."

"The need is great," he said, "not only to prove new processes, but also to be able to project accurately the expected yield once a new facility goes on stream. We leave basic chemical research to our customers; our concern is with the translation of research results to productive reality. With the facilities of our new Engineering Development Center in Newark, it is entirely possible on many jobs to project actual productive yields to within 0.01 per cent."

The new, 150,000-square foot Center greatly extends the services offered by Lummus for almost three decades at its engineering laboratory in Bayonne, N. J.

The Lummus laboratories will concentrate on unit processes and operations, the "building blocks" in chemical and petroleum plant design. Schematically, almost any new job can be considered as a series of relatively simple units. This approach permits concentration on one part of the job at a time. And it also permits translation of previous experience and technology on many of the same types of building blocks.

Typical unit operations, integral in all the complex plants built today, include heating and cooling, distillation, fractionation, contacting, filtration, and solvent extraction. Unit processes include oxidation, reduction, catalytic cracking, esterification, hydrogenation, and polymerization.

These same schematic building blocks are used, with only slight variations, in all process industries. They may even have different names when used to produce different end products.

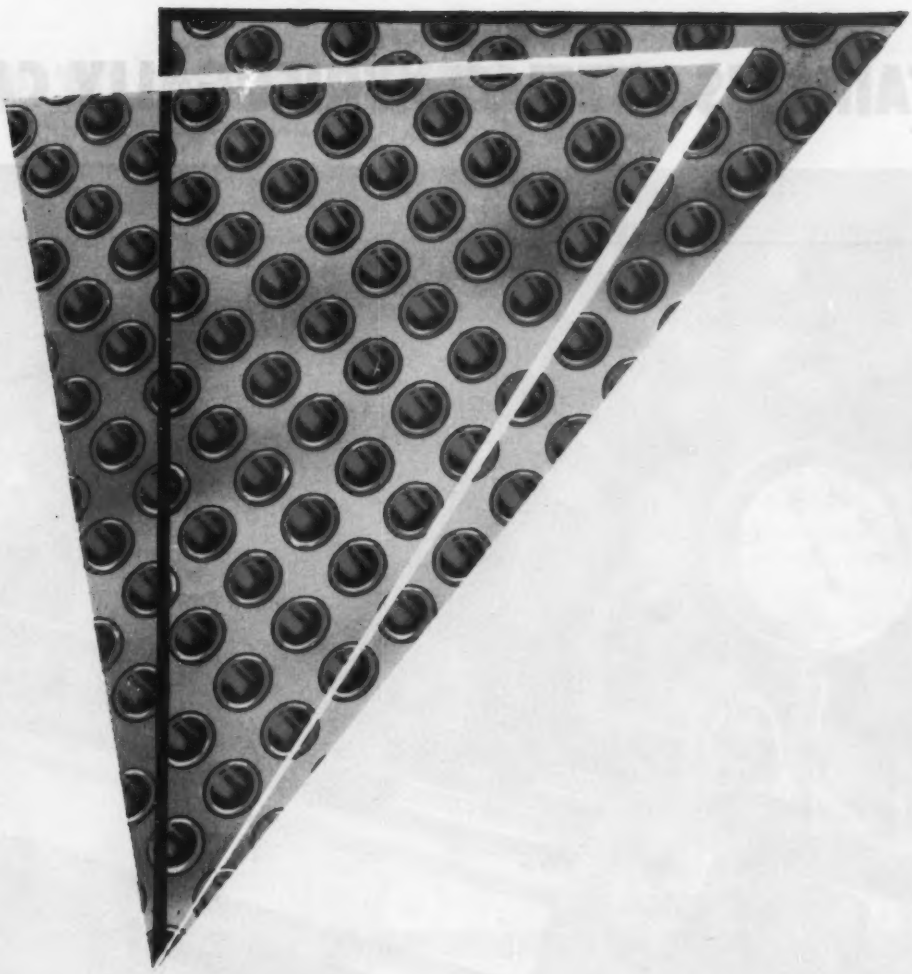
The Cooperative Refinery Association will build a hydrofluoric alkilation unit at its Coffeyville, Kan., refinery. The Refinery Engineering Co., Tulsa, will build the unit under license from Universal Oil Products Co. Actual construction is scheduled to start in September with completion slated for early 1958. Cost will be about $1 million.

Canadian Industries, Ltd., will double the capacity of its Edmonton, Alberta polyethylene plant. Construction to raise the annual capacity of the plant to 40 million pounds will begin later this year.

Societe Belge de L'Azote dt des Produits Chimques du Marly (S.B.A.) has been awarded a contract for the construction of an acetylene plant for Houilleres du Bassin de Lorraine. The unit will be erected in Carling (Moselle) and is part of a large chemical program.

Idemitsu Kosan Company, Ltd.'s refinery at Tokuyama, Japan, is virtually completed and most units are on stream.

Capacity of the $25 million plant is 30,000 bpd. Facilities include a 3,000 barrel Platforming unit and three other processes—Fluid Catalytic Cracking, Unifining and Unisol—licensed by Universal Oil Products Co., Des Plaines, Ill. UOP also



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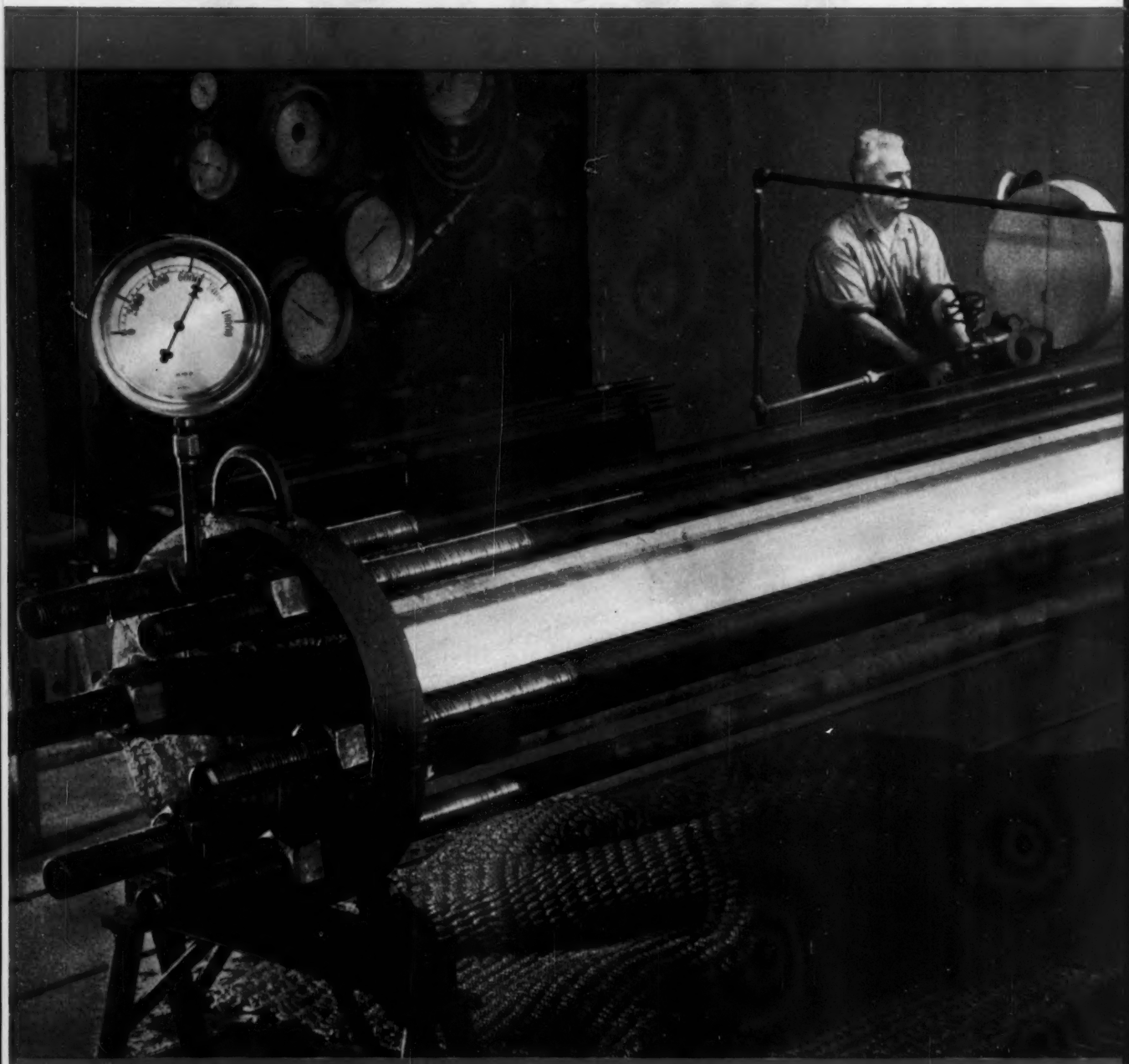

ABOVE: Hydrostatic test rig used to qualify each length of pipe.

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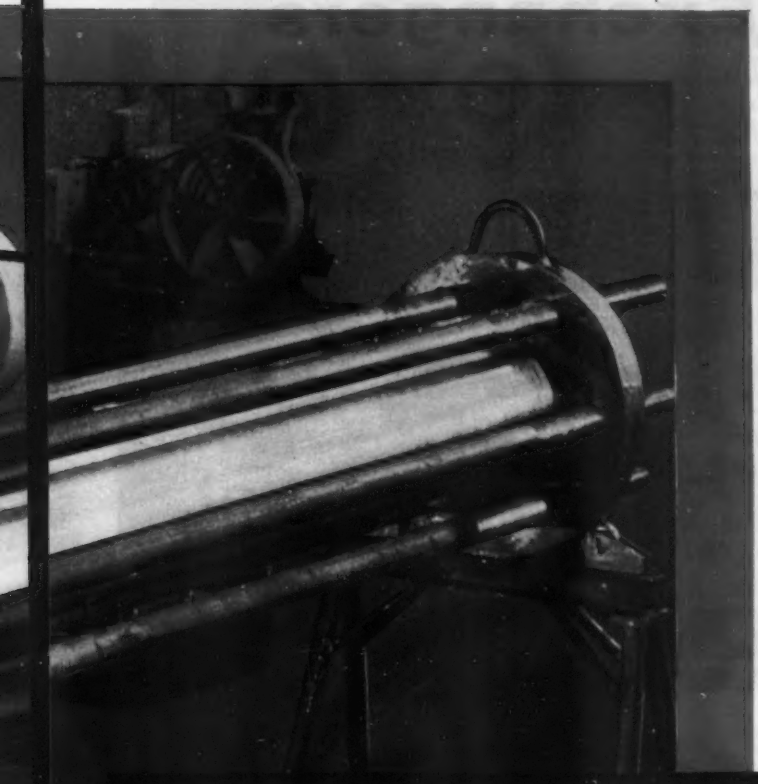

Patented U. S. Pipe process meets rigid refinery specifications

The men who design today's petrochemical plants, refineries or Atomic power plants are confronted with piping problems involving temperatures, pressures and corrosive conditions which only a few years ago would have been called impractical, if not impossible.

U. S. Pipe's Steel & Tubes Division recently completed a piping requirement for 700 feet of Type 316 Extra Low Carbon, columbium-bearing stainless for a large petrochemical plant, which is typical of the job metal mold centrifugally cast pipe is doing today under a patented manufacturing process with rigid Quality Control.

U. S. Pipe is headquarters for metal mold centrifugally cast alloy and stainless steel pressure pipe over a wide range of special and standard analyses —in large or small quantities.

Write and outline your refining problems. We may be able to help.

Note these exacting specifications on 316 Cb ELC Stainless Steel Pipe demanded by one of nation's leading oil companies:

MATERIAL REQUIREMENTS: Pipe shall conform to ASTM Specification A-362-52T.

CHEMICAL ANALYSIS: Modified AISI Type 316 Cb (ELC), with *one percent* spread on chrome and nickel.

FINISH: Each pipe to be turned, bored and faced to surface finish of 125 micro inch or better. O.D. tolerance plus 1/16″ minus 0″; I.D. tolerance plus 0″ minus 1/32″. Pipe size: 12″ O.D. × 1.17″ wall.

MECHANICAL TESTS: Tensile Tests — 2 tests required on each pipe after heat treatment; one at room temperature, one at 700° F.

INSPECTION REQUIREMENTS

1. Etching test on sections cut from each end of pipe.
2. Radiographic Inspection — Required complete circumferential coverage of at least an 8″ wide section at each end of each pipe in accordance with ASTM Specification E71-52.
3. Fluid Penetrant—Entire O.D. and I.D. surface each piece.

HEAT TREATMENT: Heat for 4 hours at 2100° F.—2150° F., water quench, follow by 5 hours at 1500° F.—1600° F. Cool in still air.

HYDROSTATIC TEST: Each length tested to stress of either 90% of the minimum cold yield strength or a maximum pressure of 6800 psi —whichever is lower.

SIZE RANGE AND COMPOSITION FLEXIBILITY

Outside Diameter—6″ to 50″
Wall Thickness—⅜″ and up
Length—Up to 16′
Types of Stainless—All Standard AISI and ACI grades of ferritic and austenitic stainless, including No. 20 Alloy, 17-4 P H, 17-7 P H and E.L.C. grades.

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Struthers Wells standard stock heat exchangers have secured a wide acceptance in the process industries.

The illustration shows a partial view of units currently in stock. Equipment is available from stock in sizes from 20 to 300 square feet of surface—including fixed tube sheet, floating head and U-tube units.

Condensers, coolers, heaters, and reboilers can be supplied in single and multi-pass tube arrangement.

Standard heat exchanger construction includes materials of carbon steel, nonferrous alloy, and stainless alloys Type 304 and Type 316. Equipment meets highest construction standards, including ASME Code and TEMA Class A.

Standardization of design and quantity production enables us to offer this equipment at a very reasonable cost.

Price sheets and standard data are available on request; please address us on your letterhead.

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designed the crude distillation unit at the refinery.

The refinery, located 800 miles southwest of Tokyo, is on the site of a former Japanese naval depot and refinery that was bombed out during World War II. Completely new from the ground up, the refinery will produce a wide range of products, from asphalt to jet fuel and high octane gasoline.

Among the unusual features of the plant is a carbon monoxide fired boiler. The CO, normally a waste material, is produced in the cat cracker.

Raffineria Di Roma will build a new refinery at Rome, Italy, to process about 30,000 barrels of crude daily. The new plant will replace an older one operated by Purfina Italiana. Raffineria di Roma was formed at the end of 1956 with Purfina Italiana, a Petrofina group member, and ENI sharing ownership on a 50-50 basis. Terminal facilities for 45,000 ton tankers are to be built.

During 1956 Purfina Italiana's Genoa and Milan refineries were further modernized. The Florence refinery was shut down permanently.

Pontiac Eastern Corp.'s Black Creek, Miss. refinery will start coming on stream next month. The 11,000 bpd plant, which will be able to convert about 70 percent of its runs into gasoline, will cost an estimated $18 million. Its crude plant will be started up in a few weeks, and its cat cracker some time in July. By fall, the entire plant is expected to be on stream.

The Texas Co. will close its Sunburst, Mont. refinery when its Anacortes, Wash. plant comes on stream. The new Washington plant, just getting under construction, should be ready by late 1958. The Sunburst refinery now has a capacity of 8000 bpd.

British Petroleum Co.'s latest refinery expansion plan will increase its total refining capacity in the U.K. to more than 260,000 bpd in 1959.

Under a new $12-million plan, BP will add another 20,000 bpd to the capacity of its 44,000 bpd Grangemouth refinery, in Scotland, by replacing its present crude distillation unit.

It will also add auxiliary refining units and extra tankage.

The total capacity of the refinery will now equal the capacity of a 57-mile pipe line that brings crude to the plant from the Finnart tanker terminal on the west coast of Scotland. BP's plans include building a new super-tanker jetty at Finnart by the end of next year.

Currently, BP is making good headway on a $73-million expansion program at Kent, its largest refinery in Britain. The plant's 92,000 bpd capacity will be increased to 140,000 bpd by the end of this year.

Frontier Refining Co. plans to expand capacity of its Cheyenne refinery from 16,500 to 22,000 bbl daily. The company also plans to double the refinery's asphalt-plant capacity to 10,000 bbl daily. Details of the expansion have not been completed.

Stauffer Chemical Co. has completed a several thousand dollar addition to its Richmond, Cal., laboratory. Stauffer will step up research on special metals, high-energy fuels and inorganic plastics.

Foster Wheeler Corp., reportedly has a finger in the 15,000 bpd refinery which will be built in Thailand. Foster Wheeler in association with Summit Industrial Corp., has submitted one of three bids for construction of the refinery being studied by the Thai government. The plant which would be built on Bangkok Harbor, would produce a full line of products with the exception of lube oil and avgas, to sell to the Thai military. It would probably run on Middle East crude.

Two other smaller plants are also under consideration for Thailand. One is a 1000 bpd topping plant which would be built inland near recently discovered production fields. No specific site has been selected for the other plant which will probably have a capacity of around 5000 bpd.

Who's Building . . .

Humble Oil & Refining Co.'s new gas processing and cycling plant to be built in Kleberg County will be located adjacent to the company's present Seeligson compressor plant. The site is approximately 15 miles southwest of Kingsville and 3.3 miles east of Ella Lee switch, just inside the Kleberg County line. The new installation will be known as the King Ranch Gas Plant.

Final selection of the site was based on economic studies made by the company to determine the location which would provide for maximum efficiency in plant

Choose from the improved DH Line of Dean Hill horizontal turbines which give you up to twice the power of earlier models while maintaining the same economy of operation.

The major change contributing to this tremendous power increase is the addition of steam nozzles to all models. On types now built with two nozzles—DH-10, DH-15, DH-20, DH-25—this change has meant *a 100% increase in the maximum horsepower of each unit!* On new three-nozzle models—DH-30, DH-35, DH-40, DH-45—the rated increase in maximum horsepower is 50%!

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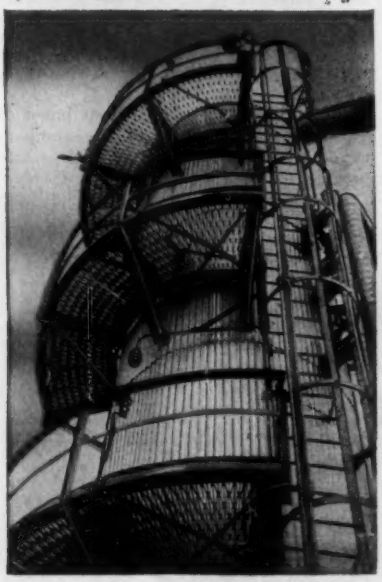
RAIN OR SNOW CAN MAKE CATWALKS DANGEROUS



Walkways, catwalks and treads made of solid wood, metal or other material can collect snow, rainfall, grease or oil and become dangerously slippery.

But these walking surfaces, made of an open mesh of metal bars on edge, cannot collect these substances, leaving the surface always clean, dry and tractional for safer access to high places.

As founders of the grating industry, the Irving Company can draw upon over half a century of experience to supply you with quality grating products for catwalks, treads and other practical and economical uses.

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Who's Building . . .

and field operations and minimum capital expenditures.

Much of the design work remains to be done, according to Humble officials. Actual construction should begin in midsummer, 1958. "Some work on the pipe lines and gathering systems, however, will probably start earlier in the year," they said.

Toa Nenryo Kogyo Ltd., Japanese affiliate of Stanvac, has begun a $12.5 million project to quadruple throughput capacity of its Shimizu refinery. Crude charging capacity should increase from 7000 to 32,500 barrels daily. Completion of a new 25,500-bpd pipestill is scheduled for December 1957. A Powerformer and Hydrofiner are to be finished by late 1958. In addition, a continuous kerosine acid-treating unit, new power-generating capacity, and additional tankage will be built.

Continental Oil Co. has completed a modernization project at its Ponca City refinery, which consists of a catalytic reformer and auxiliary facilities with a total capacity of 11,000 barrels of naphtha daily.

The new Ponca City installation is designed to improve gasoline quality and to produce light aromatics for use in the company's petrochemical manufacturing facilities.

Conoco recently completed a research pilot plant and a wax plant addition at Ponca City and currently is constructing an atomic radiation laboratory at that location.

Cities Service Oil Co. has just completed a program of modernization and expansion at its Ponca City, Okla., refinery.

The multi-million dollar program included installation of a Rexformer unit—newest process in catalytic reforming that will produce octane numbers higher than previously obtained by any other commercial process. The Ponca City Rexformer unit is the largest of its kind in operation in the United States.

Crude capacity at the refinery has been increased from 25,000 to 35,000 barrels daily.

Monsanto Chemical Co. has completed a 10 percent expansion in its production capacity at St. Louis for maleic anhydrite, a large-volume resin material which is a key ingredient in the manufacture of alkyd-based paints, other hard resin surface coatings and polyester resins.

Approximately 60 million pounds of maleic anhydride are produced yearly in the United States. Prior to the Monsanto expansion, the maleic anhydrite unit at the company's John F. Queeny Plant at St. Louis already ranked as the world's largest.

Production of polyester resins has increased from 27 million pounds in 1954 to an estimated 71 million pounds in 1956 and may reach 90 million pounds in 1957. Polyesters reinforced with fibrous glass, synthetic and natural fibers and other materials have been finding increased use in a variety of structural applications.

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★ Big Bar—All the finest liquors you can drink
★ Big Orchestra—Dancing
★ Big Buffet Supper—All the Turkey Ham and Food you can eat
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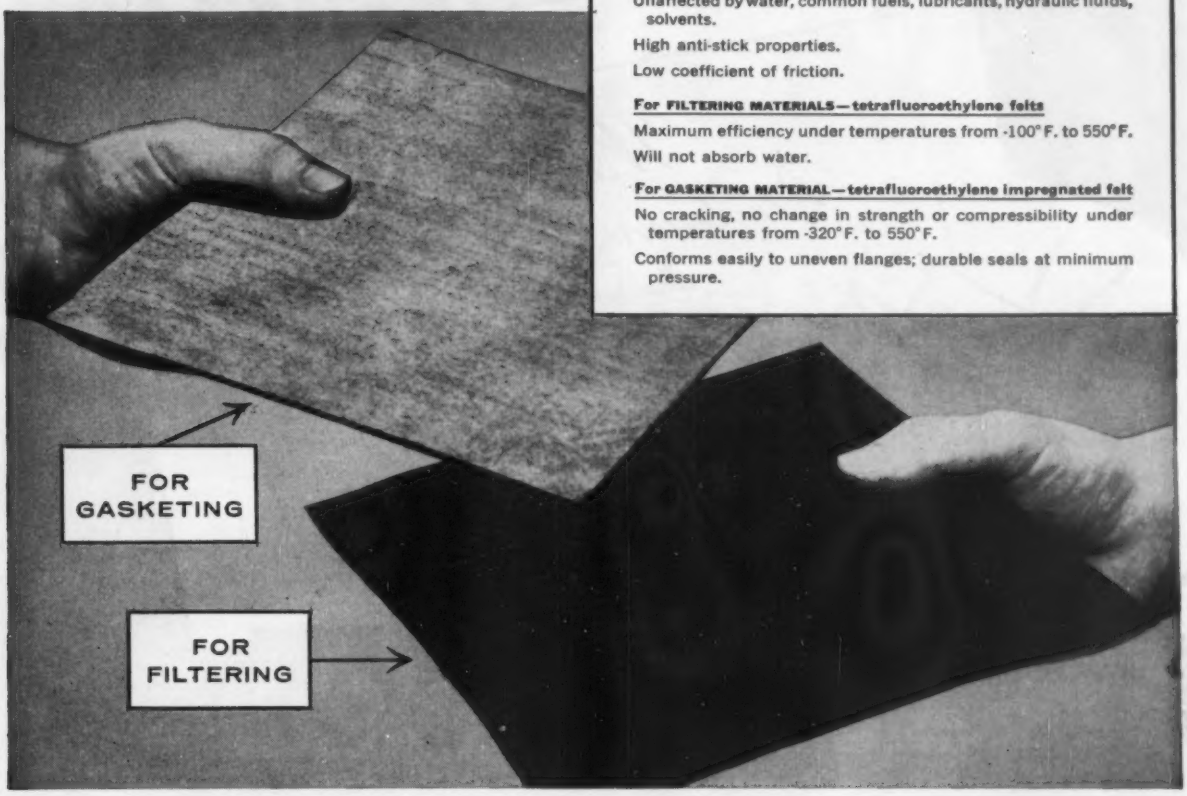

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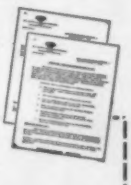

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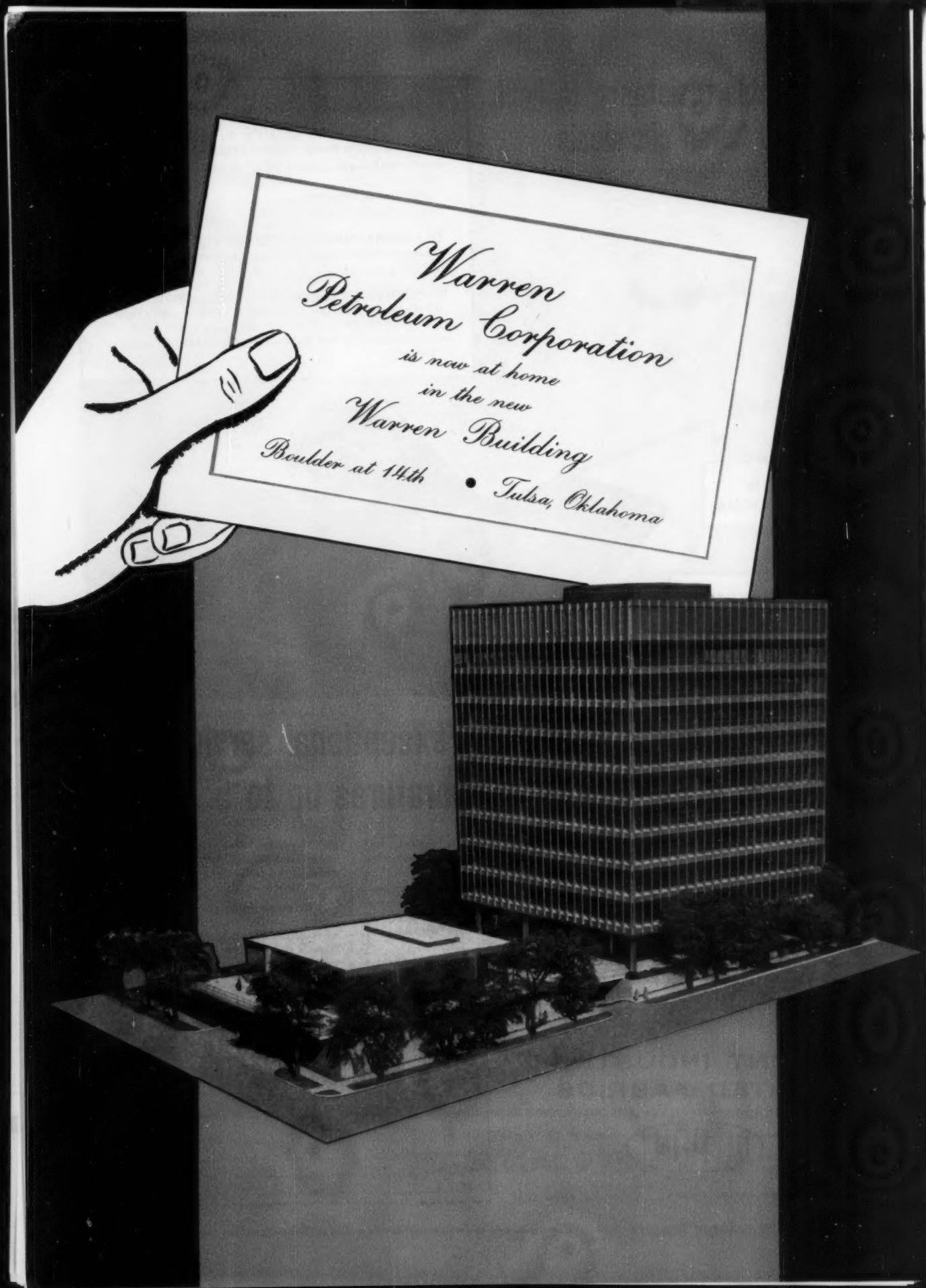
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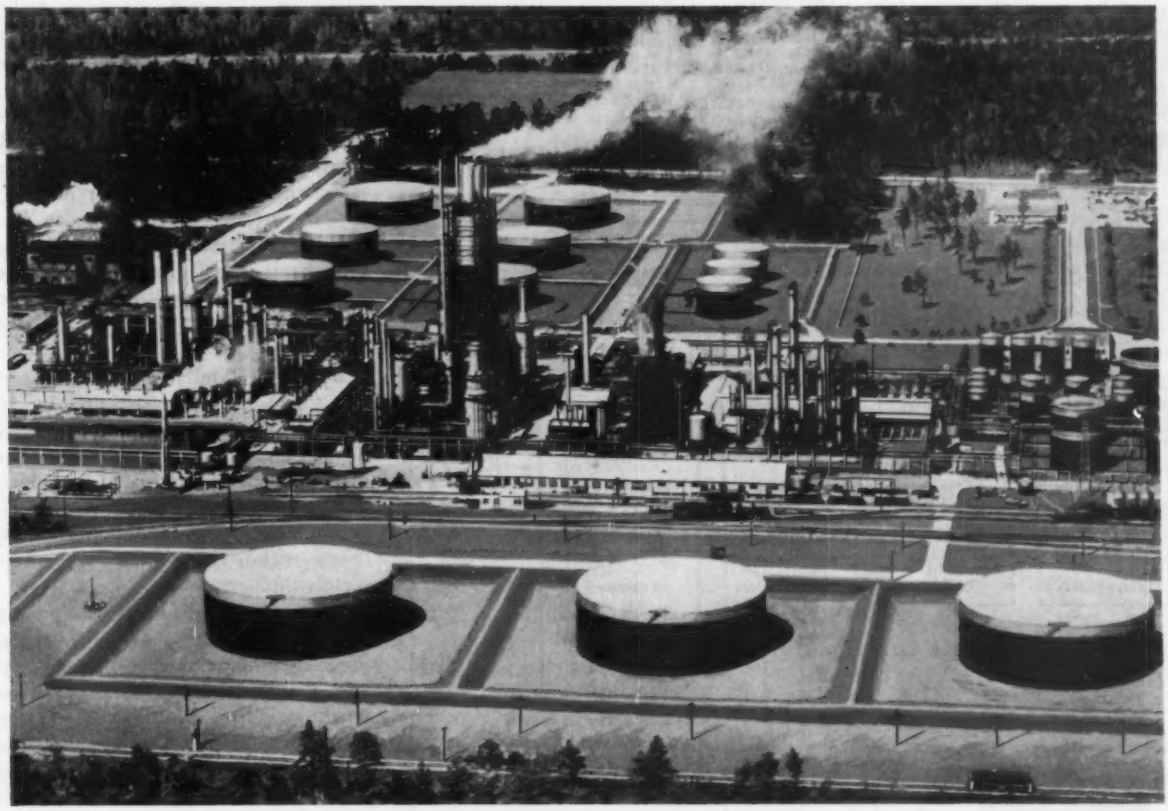


FIGURE 1—Continental Oil Company's Lake Charles refinery, though directly in the path of Hurricane Audrey, reported only $9000 damage. This plant was back on stream within 24 hours after shutdown operations were completed.

Special Report on Hurricane Audrey

Disaster Planning Pays Off

Early planning and proper timing averted major damage at Continental Oil's Lake Charles refinery.

J. M. Jones
Continental Oil Company Refinery
Lake Charles, La.

Editor's Note: *Despite the disastrous over-all effects of Hurricane Audrey, refineries escaped her fury with relatively minor damage. To give but one example, Continental Oil's Lake Charles refinery reported only $9000 damage. Was back on stream 24 hours after shutdown. This was due to:*

- *Early disaster control planning.*
- *Sticking to a pre-determined plan.*
- *Proper timing of shutdown operations.*

How these three factors were combined into a highly successful disaster operation is described in the following case history. It is also a representative report of the personal sacrifice oil industry people made to relieve suffering in the disaster area.

A similar report could be published on the disaster operations of any one of the refineries caught in Audrey's path.

First Warning. On Tuesday, June 25, 1957, the weather bureau advised that U. S. Navy reconnaissance planes had established that Hurricane Audrey was located approximately 450 miles south of Lake Charles and moving in a northerly direction at about 7 miles per hour. This did not

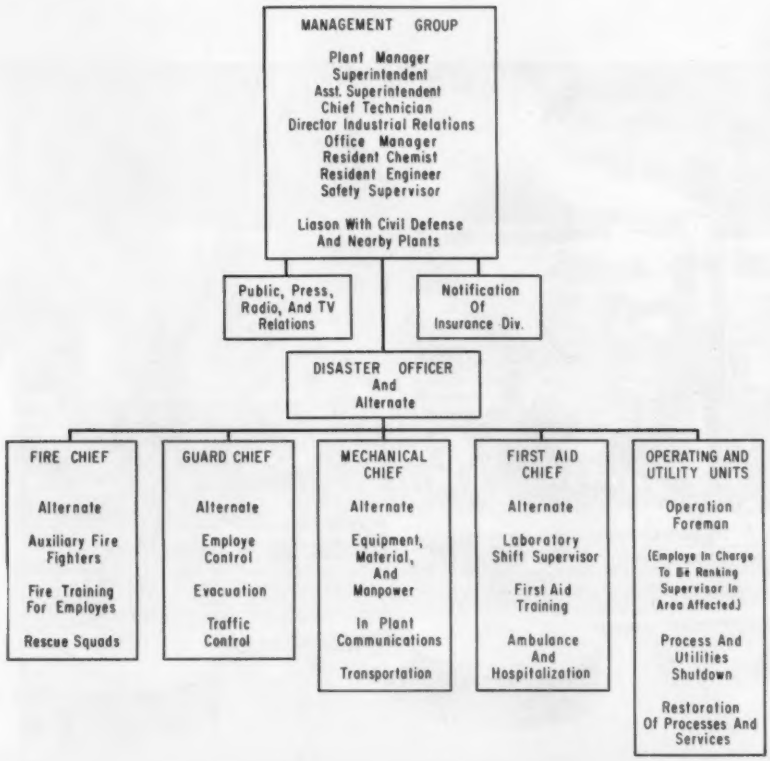


FIGURE 2—Disaster control organization that effected the efficient shutdown, personnel evacuation, and restoration at Continental's Lake Charles refinery.

cause much concern because as a rule hurricanes do not hold to a straight course.

However, by Wednesday morning it was evident that the Lake Charles area was in danger. The 10 a.m. advisory indicated the storm was still holding a northerly course along Longitude 93.5 which placed Lake Charles in its path. Through cooperation of our Lake Charles office, we were kept advised of reports from our offshore rigs. This was extremely helpful because it gave us detailed information about the intensity of the storm and this, coupled with the weather bureau advisories, permitted a close estimate of the time high winds would strike Lake Charles.

Plans were made early. The 4 p.m. advisory on Wednesday indicated the hurricane was still holding a northerly course with winds up to 105 mph near its center and was centered approximately 300 miles due south of Lake Charles, moving at about 10 mph.

At this time a meeting of all department heads and operating foremen was held to plan our course of action. It was estimated that should the hurricane hold its present course and speed, high winds would strike Lake Charles by mid-morning Thursday.

On the off-chance that it would change its course at this late time, it was decided to hold another meeting of the group at 10 p.m., at which time another weather advisory was to be broadcast.

The 10 p.m. advisory indicated the hurricane was centered 235 miles due south of Lake Charles, moving at a speed of 10 mph, and still holding a course along Longitude 93.5. CATC had reported 105 mph winds with gusts exceeding 150 mph and based on these reports, it was estimated we would be hit hard by 8 a.m. Thursday.

Plan Goes Into Action. Each operating foreman gave his estimate of the minimum time he would need to safely circulate his unit down. The Catalytic Reforming unit, requiring 8 to 10 hours, was started down immediately. It was decided to await an intermediate weather bureau bulletin which was to be broadcast at 2 a.m. Thursday, before starting the other units down.

Our plant disaster control organization was activated at 10 p.m. Wednesday. The 2 a.m. bulletin indicated no change in the course or intensity of the storm, except that it had picked up speed to 20 mph. The order was then given to cut fires, secure all units and hold them on circulation. This was accomplished by 8 a.m.

By 7 a.m. Thursday, the center of the storm hit the coast and by 10 a.m., the wind had reached a velocity of 105 mph at Lake Charles. Our disaster control organization, which had been activated at 10 p.m. on Wednesday, was functioning and things within the refinery were completely under control.

Our ambulance had been working since early in the morning, moving the bed-ridden residents of the Westlake area to the high school shelter. At the height of the first phase of the storm, the power failed in the Westlake area and several hundred refugees found themselves without water. Civil Defense notified us and our employes rounded up all the water containers, drums and cans available and we kept the shelter supplied with water.

Communications Were Spotty. During this time the power failed in Lake Charles and all local radio and T.V. stations went off the air. Telephone communications became extremely unreliable and during long periods failed completely. Our only means of communication during the rest of the storm was by means of messengers and our Mutual Aid Association short wave radio.

The messenger system organized by our disaster control committee functioned well. However, our docks were completely cut off by high water and telephone communication was extremely spotty. The seas were so high, our small outboard driven boat could not navigate. The dock crew took refuge on the S. S. Ponca City which had finished loading and rode out the storm undamaged. Several of our offshore work boats and other crafts were given refuge at our docks and suffered no damage.

During this first phase of the storm, two concrete silos, 90 feet high and 24 feet in diameter, on the new Coker job were blown down. Otherwise, the plant proper suffered only minor damage.

At this time all automotive equipment and personnel which could be spared were made available to Civil Defense in the Westlake area.

Appeals for Fuel. The eye passed over Lake Charles at about 11 a.m. and during the next hour, a relative calm prevailed. A little after noon, the backlash hit with winds up to 100 mph and torrential rains.

Appeals began to come in for gasoline to man Civil Defense and other emergency equipment. These requests were freely complied with. A total of 6000 gallons was furnished during the emergency. In the midst of the backlash, we received an appeal to get gasoline to the Gibbstown Ferry on the Intercoastal Canal where amphibious boats and other rescue craft in the Creole area were out of fuel. Bob Pumpelly, our local commission agent, furnished a truck and driver and the gasoline was delivered under the most trying conditions.

After 1 p.m., we suffered a power failure in the plant caused by tree limbs being carried across our high lines and the extreme wind velocity causing the lines to sag and slap together. This shut three of our water wells down and had we been attempting to operate our units at the time, we would have faced a most serious situation considering the intensity of the storm.

Refinery Damage Was Slight. By 4 p.m. on Thursday, the wind velocity had reduced to about 45 mph with gusts up to 60 mph. The 4 p.m. weather advisory indicated the storm was on the wane in this area with little likelihood of retracing its course and based on that information instructions were issued to resume operations.

By 6 a.m. on Friday, June 28 all units were back on stream with the exception of No. 1 Catalytic Cracking unit and the Catalytic Polymerization unit, both of which came on stream about mid-afternoon. Total damage to the plant, excluding the Coke silos, is estimated to be no more than $9000. Our personnel suffered no injuries except minor first aid cases.

By Friday morning the scope of the disaster at Cameron, Grand Chenier, Little Chenier, Pecan Island, Creole and all areas south of the Intercoastal Canal became evident. Civil Defense and the Red Cross made an appeal for individuals owning outboard driven boats to take them into the stricken area for rescue and evacuation work. Many of our employes responded and were released for this work.

Every One Helped. At 5 a.m. on Friday, our ambulance was placed in service at the city docks where sick and injured people were being brought by boat from the stricken areas. Our plant nurse met the Continental workboat, LaFourche, at the City Docks where it discharged the first load of survivors.

She worked with the medical authorities, administering first aid and giving oxygen when necessary and with many other employes practically lived at the dock through Saturday and Sunday. We furnished first aid kits, stretchers and other medical supplies, holding back in the refinery only enough for local emergency use.

Our limited communication facilities consisting of a walkie-talkie radio and public address speaker system were turned over to the various agencies working at the city docks.

Two refinery employes were dispatched with emergency first aid supplies to travel with the LaFourche with instructions to do what was necessary and to communicate with the refinery by short wave on anticipated needs. Numerous requests for provisions and supplies were made and taken care of.

Ammonia and Face Masks. On Saturday, the dead began arriving at the city docks where a morgue was set up in one of the large sheds. Identification of the bodies was extremely difficult and in most cases not possible, which resulted in the bodies being kept much too long in the intense heat.

Our nurse organized several of our employes and other volunteers at the city docks into a group which made 2500 gauze face masks to be worn by people trying to identify the dead. We furnished ammonia from our refinery stocks to be used with the masks. We also furnished a substantial amount of lime.

Our vacuum truck was sent down to Cameron Sunday night and has been used since that time in the more critical preliminary phases of cleanup work. On July 4, a group of 100 of our employes went to Cameron and worked their holiday, helping the cleanup crews. Club Continental, an employe organization, donated $1000 to Cameron relief instead of holding a picnic which they usually have on July 4.

I cannot say too much for the manner in which our employes conducted themselves during and subsequent to the storm. Morale was high, everyone kept his head and did his job well during the storm. I have never witnessed a better demonstration of unselfish personal effort to pitch in and help the community than was shown by our people. We have every reason to be very proud of them. # #

About the Author

J. M. JONES, manager of Continental Oil Company's refinery at Lake Charles, La., has been a Conoco employe for more than 31 years. After graduation from Johns Hopkins University, he spent four years with two other oil companies, then in 1926 he joined Conoco as a chemist at the company's Baltimore refinery (now a petrochemical plant). He rose to assistant superintendent and then became superintendent of the Baltimore refinery in 1946.

Jones served at Baltimore until May, 1950, when he was promoted to superintendent of Conoco's Lake Charles refinery. He was named manager of that plant in October, 1954.

Why Have a Refinery Safety Program?

Four factors can make or break a safety program:

- **The way it is organized.**
- **Status of management-employe relations.**
- **Attitude of employes and management.**
- **Quality of management leadership.**

The article on these pages—and the next two in the Risinger series—will provide all the essentials for an effective safety and fire protection program. The first article explains the need for safety and fire protection. The second will outline the essentials of an effective safety program. The third, how to organize a program in both large and small companies.

The material presented in this series is the result of more than 30 years experience in oil industry safety and fire protection. Joseph Risinger, one of the nation's top safety and fire authorities, recently retired from Socony-Mobil Oil Company to enter private consulting work.

J. L. Risinger
Consultant
Maplewood, N. J.

THERE ARE TWO causes of accidents:

- Faulty environment.
- Faulty human behavior.

Analysis of these causes reveals the symptoms of ailments which not only cause accidents, but also retard a company's efforts to obtain quantity and quality production at the least possible cost consistent with employe and public good will.

From a study of many safety programs, certain basics have revealed themselves and certain principles found to be present in each successful program. Likewise, they are absent from unsuccessful programs. Too many personal injury accidents and too many fires have been found not to be ailments themselves, but symptoms of ailments that affect more than the accident and fire record. In some cases the symptom itself is treated and does some good temporarily, but the ailment remains until treated and cured.

Since the 10 percent of accidents that can be prevented by mechanical means only also depends on human procedure, the ailment revealed by the symptom (too many accidents and fires) is a human ailment. Therefore, it stands to reason that each member of management is involved in direct proportion to the scope and authority of his job.

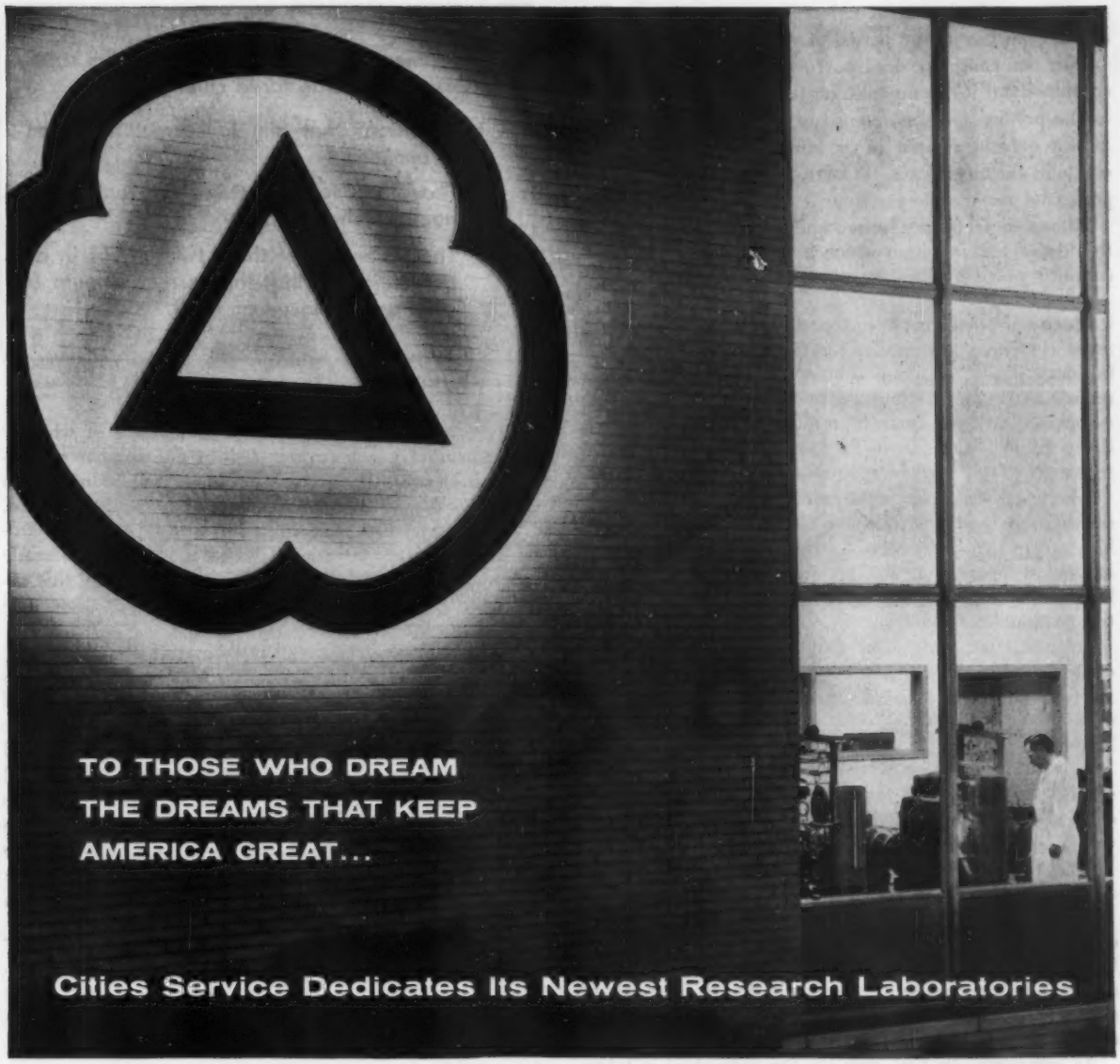
Invariably when the X-ray of investigation has been turned on a good safety record, in back of the symptom is found correct organization—good relations—correct attitude—and leadership from both line and staff management. This applies not only in the safety function, but in others as well.

In dealing with the two causes of accidents, some organizations place heavy emphasis on faulty environment such as equipment, guards, tools, machinery and even to the neglect of the human equation. On the other hand, some place all the emphasis on correcting faulty human behavior, neglecting the correction of faulty environment.

With these facts in mind, the fundamentals of an industrial safety organization might be stated as containing three chief factors:

1. Provisions that aim to correct faulty environment.
2. Those that aim to correct faulty human behavior or to prevent it.
3. The balancing of these two factors in organization so that the correct amount of emphasis is placed on each.

Money Can't Pay for Lives. A company might permit certain defects in production to exist in its operations if management is willing to pay for it. A company might even permit some individual to fall down on results from



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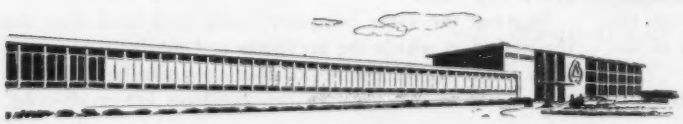

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a profit standpoint and condone it because the employe or manager has a long period of service.

But, the company does not own the life and limb of employes and it has no lease on the life, limb or property of the public. Thus, no company has the right to permit known defects to exist in its safety organization, nor to condone the negligence of safety personnel or operating personnel responsible for safety.

Known defects, negligence and shortcomings result in the loss of life and limb which a company does not own, cannot replace and can never pay for with money.

Reduced Accidents Are Good Business. The statement is often made that a good safety program is good business. This statement is often construed in terms of money that would otherwise be paid out as workmen's compensation to the man injured, insurance to his family if the injury is fatal, or in the case of fire loss, the cost of repairing or replacing the property involved.

There are still a few safety men who say that to interest the boss in safety you have to show him that it saves him money. In other words, that the program is reducing the compensation and incidentals he has to pay for loss of life and other injury to his employes more than the program is costing.

It is difficult to conceive that the company executives could feel that if it would cost more to save the life of an employe than to pay for his death, the latter course should be taken. Although this is not the intended meaning it was formerly so construed and sometimes still is.

It is also feared that in some cases in the past, the cost of safety was figured strictly on the profit and loss basis even though it included human life and happiness. This was, no doubt, one of the reasons for the public's action in terms of compensation laws, making it good business to prevent accidents.

If there are still those who figure safety expenditure of effort and money on this basis, then compensation should be set at a substantial cost to force a greater consideration of accident prevention. If some still figure in terms of money, then prevention should be made to pay in terms of money.

As compensation cost goes up the individual is taken out of the scope of expendability in economic competition and his safety becomes more of an economic factor. When this is set to a maximum, then the statement that safety has proved to be good business, with no point of diminishing returns, will mean that such a company is approaching the complete fulfillment of its responsibility to its employes and to society.

How Much Is Safety Worth? Since compensation cannot be set at a point beyond which expenditures cannot be justified on a money basis, the requirement that a company shall or shall not go beyond this point of diminishing returns must be left to the court of employe and public opinion. The decisions are rendered in terms of condemnation or good will. There is no question but that these weigh heavily against or for a company. This is indicated by a practice during recent years of giving an account of safety in annual stockholders' meetings of oil companies.

The question then of how much should be spent on a safety program should be answered in terms of whether the expenditure will further reduce the number of personal injuries rather than whether it will reduce them enough to absorb the cost in terms of compensation saved.

Fundamentals of an effective industrial safety organization include three chief factors:

1. **Provisions that aim to correct faulty environment.**
2. **Provisions to correct—or prevent—faulty human behavior.**
3. **The balancing of these two factors in organization so that the correct amount of emphasis is placed on each.**

It is recognized that much money is expended unnecessarily by misdirection. This is a handicap to ready acceptance of sound recommendations. Much of this expenditure is directed to prevention of very remote possibilities or impossibilities.

For instance, a job was slowed down and extra expense incurred by the requirement that copper or wood tools be used to scrape the roof of a tank, the contents of which would not give off vapors unless heated to over 300 degrees. Furthermore, it is considered that steel hand tools would not have provided the required energy and spark to ignite the vapors if they had been present. While taking this unnecessary precaution against explosion, no planks were laid on the rusted-out roofs of the tanks to prevent the workmen from falling through. One man actually did fall through while scraping the roof of an empty tank.

Of course on the fire protection angle where safety of employes are not involved or the hazards to them have been removed, the amount to be spent can be calculated on the basis of whether the fire loss will be reduced more than the expenditure required to obtain it. (See Part 6, June, 1957.)

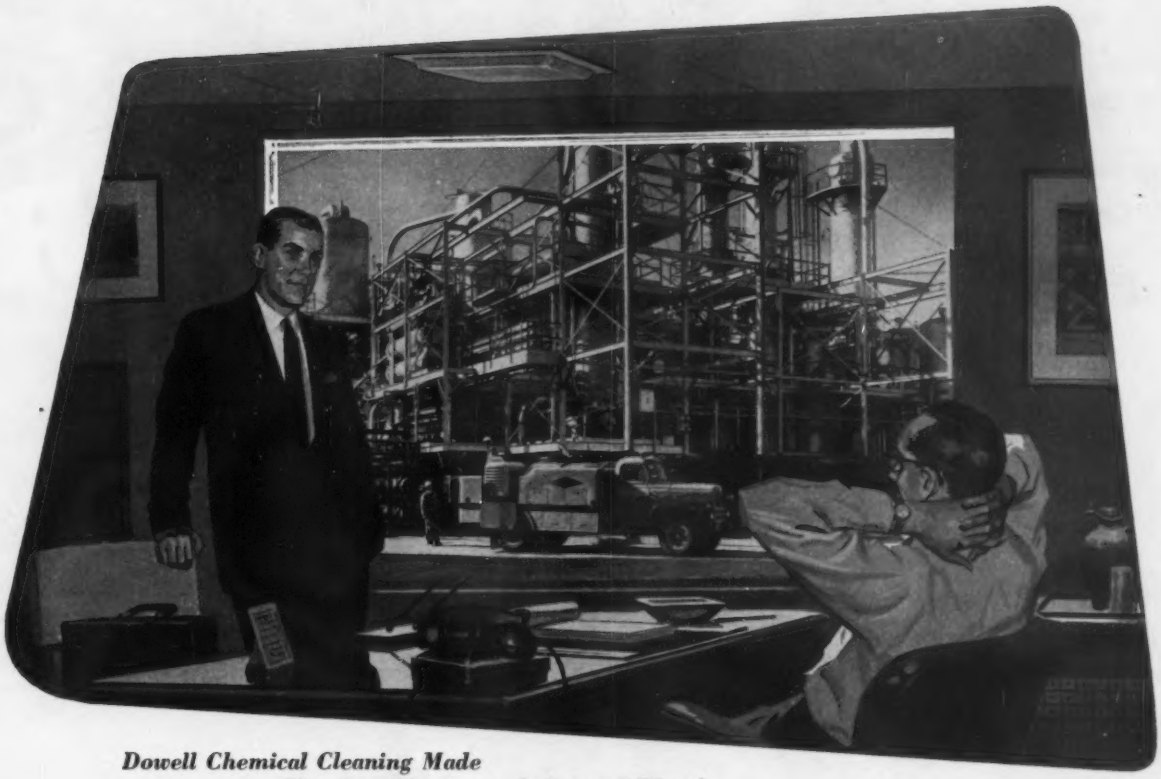
The question has been asked, "How much can a company afford to spend to reduce the frequency rate of personal injuries from 5 to 1?" Answer: Such an expenditure should be based on whether higher expenditures *will reduce* the accidents rather than the expense.

The same would be true on the reduction from one to zero. Why? Because there would be no limit on the expenditure if, after the accident had occurred, such expenditures would give a person's life back to him or even restore him completely after a serious injury.

To expand this thought even farther, suppose a company has an accident frequency of four personal injuries per million man hours. If 20 million hours are worked, 80 employes will be injured and approximately 8000 days lost from the job. At least one employe will be killed every 1½ years.

Suppose the same company could turn back time for the period in which the accidents and fatalities occurred. How much would the responsible executive be willing to pay to cancel out some of the accidents before they oc-

how would you like to add $250,000.00 to your profit?



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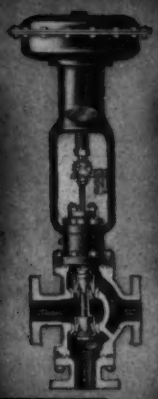

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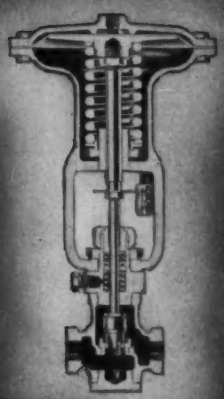

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LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

curred? How would the employes react if asked to volunteer to supply the accident or fatality list?

Objectives of a Safety Program. It is recognized that lives, limbs and homes saved and suffering and worry prevented are the chief dividends of safety.

The fact that accident and fire prevention is also good business from an economic standpoint does not detract from a company's or a department's sincerity in pursuing its human objectives and carrying out its humanitarian safety policy. The statement that effective accident—fire prevention and fire control are really good business is no longer debatable.

The objectives of an industrial safety program are so tied into the company's objectives and so much a part of them, that both are nearly synonymous. The only reasonable excuse for the existence of any company is to produce and distribute products of use and service to the progress and well being of mankind. The company operating toward this purpose must invariably have the following objectives: to obtain quality and quantity of production without damage to property or injury to persons and at the least possible cost and consistent with employe public good will.

No business is operated solely for the purpose of the prevention of accidents and fires, but their prevention is essential.

It was once thought that a company's safety program was complete when it took into consideration measures to eliminate obvious death traps from the areas where employes worked. This idea has long since been discarded, but it is feared that a few companies still place too much emphasis on this phase of the subject to the neglect of the living and activating part—that of people.

There is no longer a question of whether a company has a safety program—this is demanded by the employe group and the public. It is therefore, only whether such a program is effective to the extent of the greatest dividends for the effort and expenditure.

Safety Is a Challenge. A safety program is like a jig-saw puzzle. It takes more than one or even several of the parts to reveal the picture. The parts must be fitted together correctly and each part is dependent on the others for its effectiveness.

If a safety director were asked if safety posters prevent accidents, his answer would probably be, "That depends on how they are used and what else is used." This would be true with respect to many items including safety records, machine guards, inspections, etc., the combination of which would most assuredly be effective, whereas singly their effectiveness would be very indefinite.

In consideration of a large company composed of field units, the over-all jig-saw puzzle must clearly provide all of the parts for a bird's-eye view and the parts must be fitted together correctly. Close-up detail will have to be added in the field where the accidents are to be prevented.

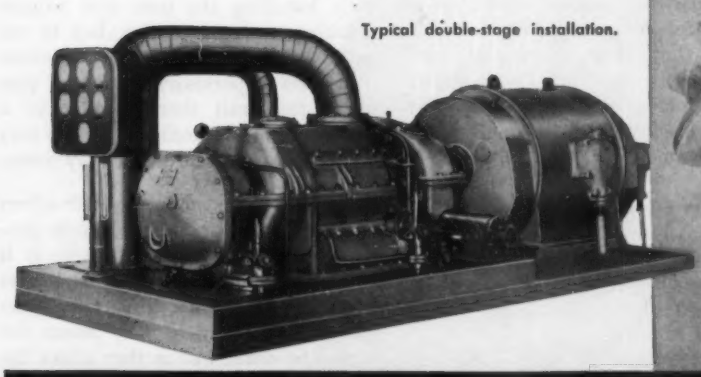
In short, the principal unit in industrial safety and fire protection is the individual company—and within the company the individual plant, location, area or other subdivision in accordance with management control.

How to put the parts of an effective safety program together, in accordance with company objectives, will be discussed next month.

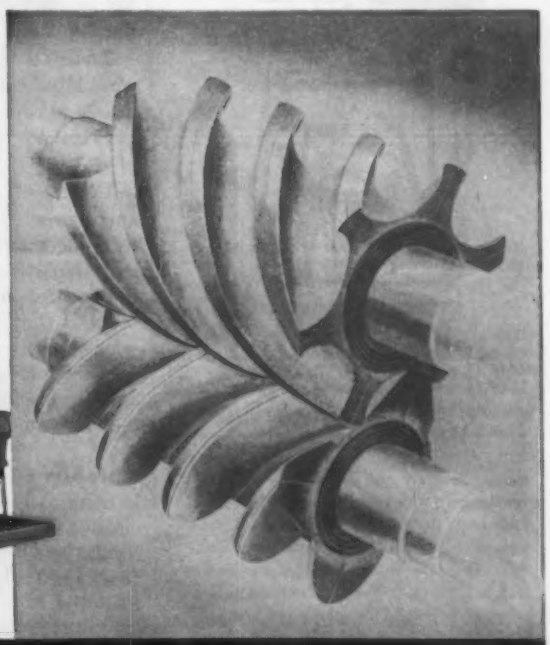
Part 9 will appear in September Petroleum Refiner

SCREW ENGINES

for oil-free handling of air and many other gases. Flow rates range from 350 to 15,900 cfm. Pressures up to 155 psia.



Typical double-stage installation.



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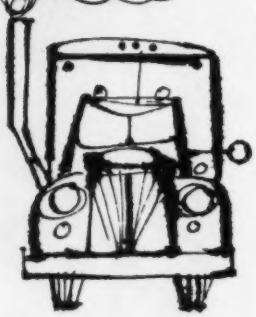
pull more diesels to your pump –deliver full power without noxious exhaust odors –just add Alamask® to your diesel fuels



It takes very little Alamask to subtract the choking odor from diesel exhaust fumes while adding to your sales. Alamask in your fuel will pull truckers, bus operators to your pump. *Selling point to truckers:* operators who tank up with your odor-controlled diesel fuels avoid the increasing demands to "put a stop to engine odors or reroute your lines." *Selling point for buses:* lines that standardize on your odor-controlled fuel increase passenger comfort both in the vehicle and in the terminal—builds good will all along the route. Why not call us about adding Alamask to your diesel fuels? Let us show you how Alamask can give you a new competitive plus.

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What Makes A Good Supervisor?

Here is a summary of 28 standards management uses to select supervisors and department heads. Check them and see how you stack up.

SO THERE's a new supervisor or department head post coming up in the company and a dozen candidates to choose from. What shall you look for in each to make certain the best possible man is selected?

Securing the best individual is always important; hit and miss selection nearly always overlooks the man who has most to contribute to the job.

Many executives are well aware of this. They have, through experience and counsel, devised definite standards to guide them in selecting supervisors and department heads regardless of the level of the position. From a summary of these time proven and tested selection factors, here is a list of qualities management looks for when selecting supervisory personnel in both the large and the small business.

Absolute Company Loyalty. No individual can deliver maximum efficiency without full and complete loyalty to the firm for which he works. It should rank topmost on any executive's list.

Cooperativeness. There was a day when the ability to give and take, to work smoothly with others and to practice cooperation in getting things done were unnecessary in a supervisor or foreman. Those days are gone forever. To secure maximum results with least effort the good supervisor today must have the ability to take as well as give orders.

Popularity. People follow such an individual because they like that person. This makes supervision much easier than where it has to be forced because of the lack of such personal popularity.

Ability to Get Along With Higher Ups. Good supervision calls for not only handling the men and women working under a person, but to coordinate their efforts with executives. Wherever supervisory personnel possesses this trait there is always a smooth flow of planning from the very top of the company all the way down.

Sociability. Getting along with others is a natural instinct some people possess and others do not. Where it is present in an individual he is always better fitted to size up situations quickly, not only as they affect the job to be done, but as they affect the people who are to carry out the details of each assignment.

Works Harder and Longer Than Others. The man who does only what is required to hold onto the present job seldom has the makings of

LIQUID MUSCLE FOR INDUSTRY

High on the list of American business achievement stands the swift efficient movement of millions of tons of material – made possible by an endless variety of automatic, time-and-labor saving machinery. Petroleum plays a vital role in this development. In the hydraulic cylinders of lift trucks, for example, move petroleum liquids that revolutionized the art of fast, cost-controlled distribution. Texaco scientists pioneered in creating these amazing hydraulic fluids which change pounds of pressure into tons of lift. The chemical sinews of these liquid muscles are the result of a partnership of research and industry in which Texaco scientists daily seek the new way, the better way.

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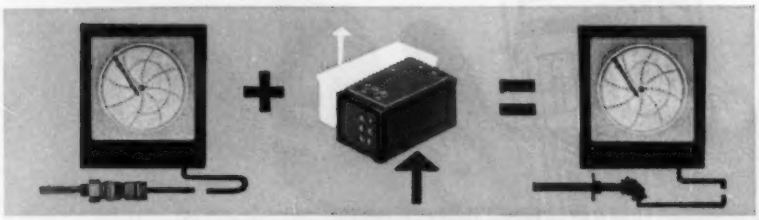
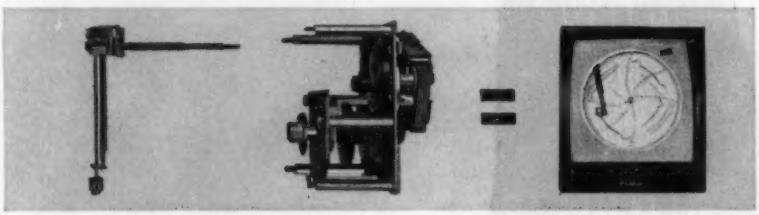
Look How the Fielden Recorder Converts into Many Instruments



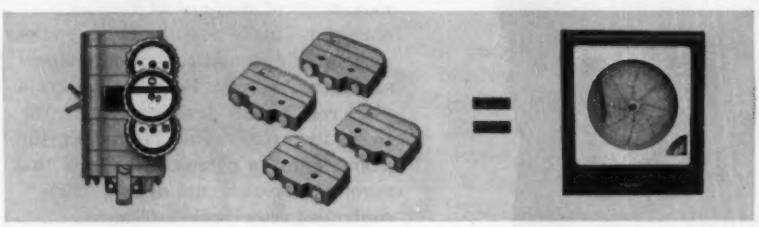
now it's a different instrument

The same Fielden Single-Point Recorder can be provided with a variety of ranges and circuits for measuring an unlimited number of process variables. By changing only the input conversion unit and rebalance elements, the Recorder can be converted to an A. C. Null Balance Circuit, a D. C. Null Balance Potentiometer, a Continuous Balance R. F. Capacitance Bridge, or a nonlinear circuit.



now it's a multi-point recorder

Without modifying the basic electro-mechanical mechanism, all Fielden Single-Point Recorders can be converted to record up to 96 points on one circular chart. Cost per point is the lowest available. All that's required is to replace the pen with a Fielden "Turret" Pen Assembly and then add a Segmental Chart Drive Unit and simple switching panel.



now it's a recording-controller

Fielden Single-Point Recorders accommodate any one of nine pneumatic control units. Add a unit, and the recorder becomes a pneumatic on-off controller or a pneumatic proportional controller with any combination of proportional, reset and rate actions. Just as simply, up to 4 SPDT switches can be added for a wide variety of electric control actions.

The "building block" approach to instrumentation is only one of many advantages Fielden instruments now bring to the indicating, recording, controlling, monitoring or scanning of practically every measurable variable. Along with its ever-growing variety of instruments, Fielden also offers a full line of sensing elements, accessories and supplies.

SEND FOR LITERATURE

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FIELDEN INSTRUMENT DIVISION
Dept. W, 2920 N. 4th St., Philadelphia 33, Pa.

"Works harder and longer than others"

a good supervisor, even in a modest spot. The one who works harder and longer than others can always be depended upon to exercise the same qualities in a supervisory position.

Judgment. This is a most important factor in selection of supervisors of any kind or type. It is evident in the common sense one uses in handling the everyday problems of the job one now has. Possessing it is assurance that such a person can render decisions in a supervisory spot without delay.

Verbal Facility. A command of words is important, to some degree, in good supervision. The man who can speak with clarity, put together phrases and sentences so that their meaning will be understandable beyond any doubt is always assured of more accurate compliance from those who carry out the details.

Evidence of Self Education. The employe who has shown positive efforts toward improving his business position in the past can always be depended upon to continue doing so in the future. He is always better prepared to handle a supervisory position.

Aggressiveness. The persistence to see any problem through to its final conclusion is a very necessary quality in any good supervisor. The individual who has shown little sign of aggressiveness in his job to date is very unlikely to show any in the future.

Possesses Friends as Well as Enemies. "He would be an excellent man —everyone likes him—hasn't a single enemy in the world," is a very nice compliment to pay any individual

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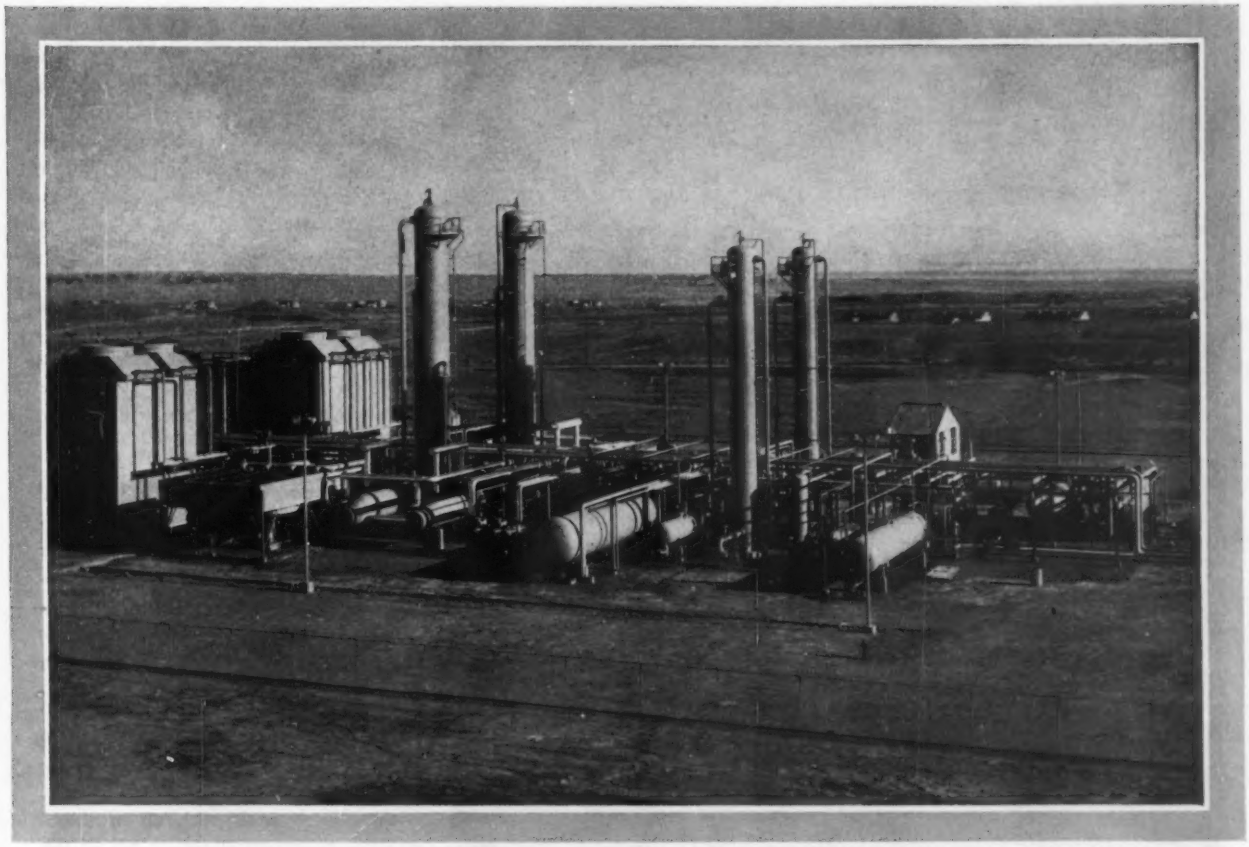

Sui GAS STARTS TO KARACHI

This plant, the first of its kind in Asia, is located in the Sui Gas Field 350 miles northeast of Karachi in West Pakistan. It processes sour gas, removing sulphur compounds and water vapor, preparing the gas for transportation and consumption. It is a vital part of a project from which will accrue great economic advantage to Pakistan.

The work of Hudson included design, procurement of equipment, transportation, and erection using English, American and native labor.

Despite the remoteness of the plant site, the rail terminus being 40 miles across the desert, and air temperatures as high as 125°F. in the shade, the plant was completed in 12 months from start of design work.

Hudson is proud to have collaborated with Pakistan Petroleum, Limited, and Sui Gas Transmission Corporation in the successful completion of this first project of its kind in Asia. The experience of Hudson gained in over 30 years in design and construction of oil and gas processing plants in the United States, Europe, Mexico and South America is available for any project large or small in any part of the world.

HUDSON
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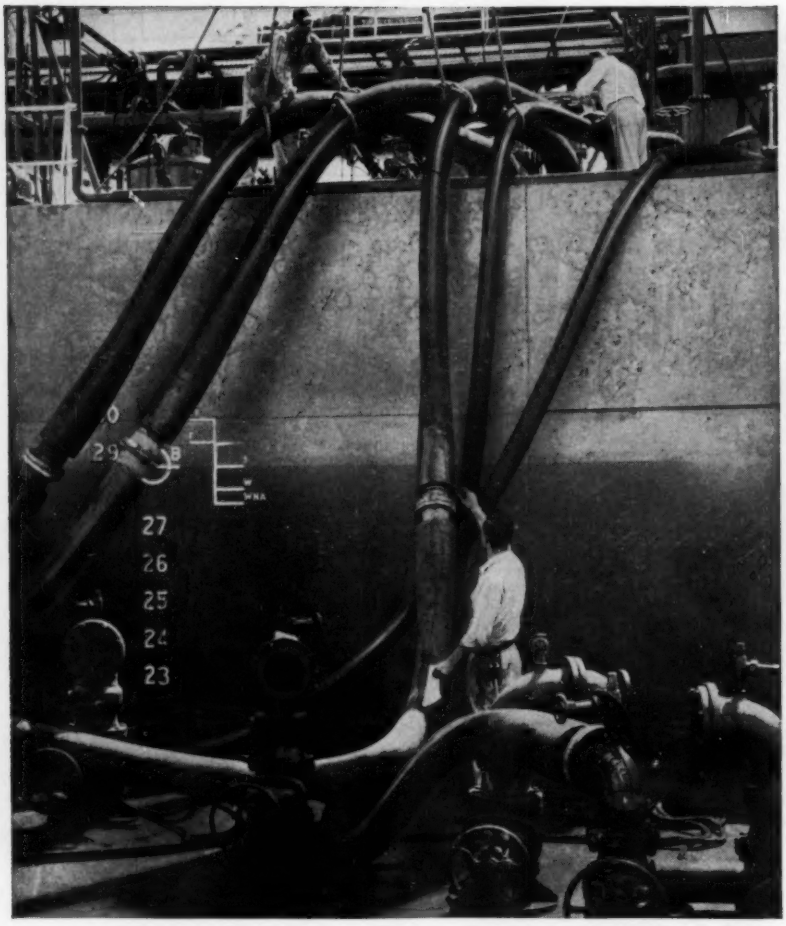

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for loading and unloading oil and gasoline from barges and tankers!

- *Won't kink or crush!*
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For more information about new Quaker Qua-Flex Oil Transportation Hose—flexible, lightweight and rugged—see your Quaker Rubber distributor today!

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under consideration. However, the man who gets things done is seldom able to do so without making enemies at one time or another. Too many of the latter, of course, is a sign of weakness. Our candidate will seldom be without them if he possesses the qualities which make for good supervisory personnel.

Humor. The good supervisor is never a wise-cracking, joke-telling personality; but he should definitely possess a good sense of humor. It relieves tense situations which he will have to handle.

Experience. Experience in the field or in the job can never be left off any such check no matter how many other fine qualities the candidate may possess. Without it the firm must wait patiently while that experience is acquired and that can be a long drawn out and very costly procedure.

Lack of Prejudices. This is a world loaded with prejudices of all kinds, manner and shape. The good supervisor has to work with all of them. He can never get the most out of the men on the staff when held back by fixed prejudices with regard to race, creed, religion or anything else.

"Possesses Originality"

Originality. This valuable quality enables one to figure out the best way to do things and not to proceed chiefly on a basis of imitation or to supervise solely on a program of following precedent. It assures the ability to come

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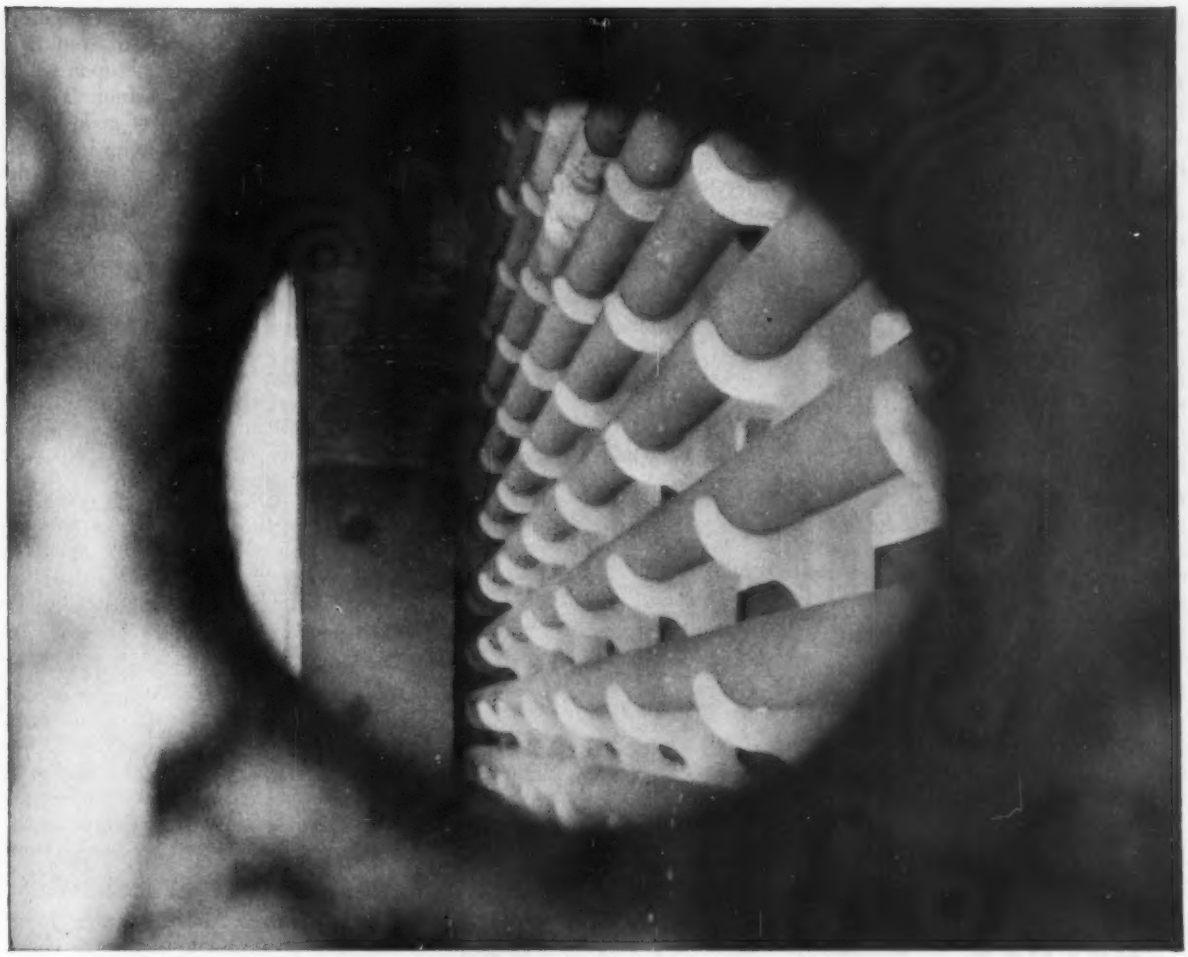


A peep inside shows...

Why Gulf puts Incoloy alloy tubes in hottest zone of heaters

The condition of these extruded Incoloy* nickel-chromium-iron alloy tubes speaks volumes.

No cracks. No warps. No thick scale. These tubes have seen thousands of hours of service in cracking hydrocarbons to produce ethylene at Gulf Oil Corporation's million-pound-per-day capacity Port Arthur plant. At this same plant their performance has been duplicated many times over.

After 9000 hours service from Incoloy alloy tubes in one group of furnaces, for example, Gulf stated: "Maintenance has been very slight ... mainly replacing one or two feet at the outlet end of several tubes" (an easy repair with weldable Incoloy alloy.)

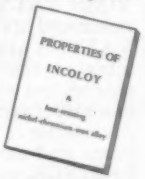
One thing that makes Incoloy alloy so reliable in this service is the stability of its austenitic structure. Another is its high resistance to carburization ... a safety factor during decoking.

Gulf also realizes a distinct price advantage in using Incoloy alloy tubing in the relatively inexpensive extruded form.

*Registered trademark

Booklet briefs Incoloy data

Information on the composition, properties, fabrication and heat treatment of Incoloy alloy have been briefed for you in the Inco booklet. "Properties of Incoloy." Let us know if you would like a copy ... or if Inco's Development and Research Division can be of service.



The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

INCO

Incoloy... *for heat-resistance*

up with the idea that sets patterns rather than follows them.

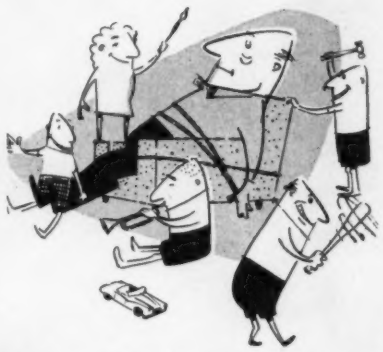
Liveliness. This demonstrated quality means that a candidate for supervisory position will work hard and play better along with having the energy and vitality to handle the toughest and most exacting assignments in the future.

Knows His Job. That's always a good check on quality of an individual. We can never expect performance in a new post from the man who has failed to conquer the problems of his present position. He will show the lack of ability to do so in the new post given him every time.

Desire to Excel. This is most important in good supervisors. It determines the quality of job performance every time. It is demonstrated by the goals the individual seeks. It is shown in how his aspirations give the drive needed to get the job done.

Self Confidence. It helps a supervisor make up his mind decisively and promptly. It inspires the same quality in those who must carry out details of the assigned task. Its lack means weakness and loss of respect from the staff.

A Degree of Success in Personal Life. The man with a mixed up personal life seldom achieves any degree of success in even the most minor supervisory role. Those of us who cannot solve our personal life problems seldom possess the ability to solve the more difficult business problems which are a part of such positions.



"Enjoys a degree of success in personal life."

Good Health. When other qualities are equal between given candidates this is always a good one upon which to make the specific decision. The individual in possession of good health and who works at keeping it can always be depended upon to have the physical equipment required of a supervisory position in the future.

Seldom Reverses Decisions. Results in any given firm come when supervisors are sure of their orders and plans, and members of the staff know that they will be followed through. Overhead costs rise where the staff can never be sure a given supervisory decision will stand and not be changed tomorrow.

Age. The smoothest running departments have always been those in which supervisors are older than the men and women working therein. It's a human trait to respect those who are older.

Ability to Explain. Many of us can give orders but at the same time, adequately explaining the reasons behind those orders is not always a quality we possess. The supervisor who can do so is always assured maximum results will be obtained from every assignment.

Intelligence. Above average intelligence is always a quality to check in any candidate for a supervisory position. It is also wise to guard against selecting an individual with intelligence far above that needed for the job.

High Frustration Tolerance. An absolute requirement for a good supervisor. Even temperament is basic requirement of the job. The man who can tolerate nothing but perfection all of the time seldom attains the overall results desired by any progressive business firm.

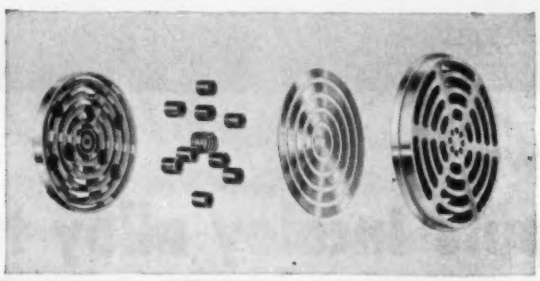
Appearance. Good supervisors do not have to be movie stars in appearance, but they must be the type of people who give attention to their personal grooming. It inspires respect from others.

Emotional Balance. Possession of this quality is always to be desired in any supervisory personnel. The man who can win without exalting and lose without moping always has a smoother functioning department.

##

VOSS VALVES

in your machine mean



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for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

VOSS VALVES are made to specification, machined from solid stock (not cast) — VALVES and PLATES are of heat-treated alloy or stainless steel; PLATES are machined, not stamped, and ground for precise close-tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS, of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

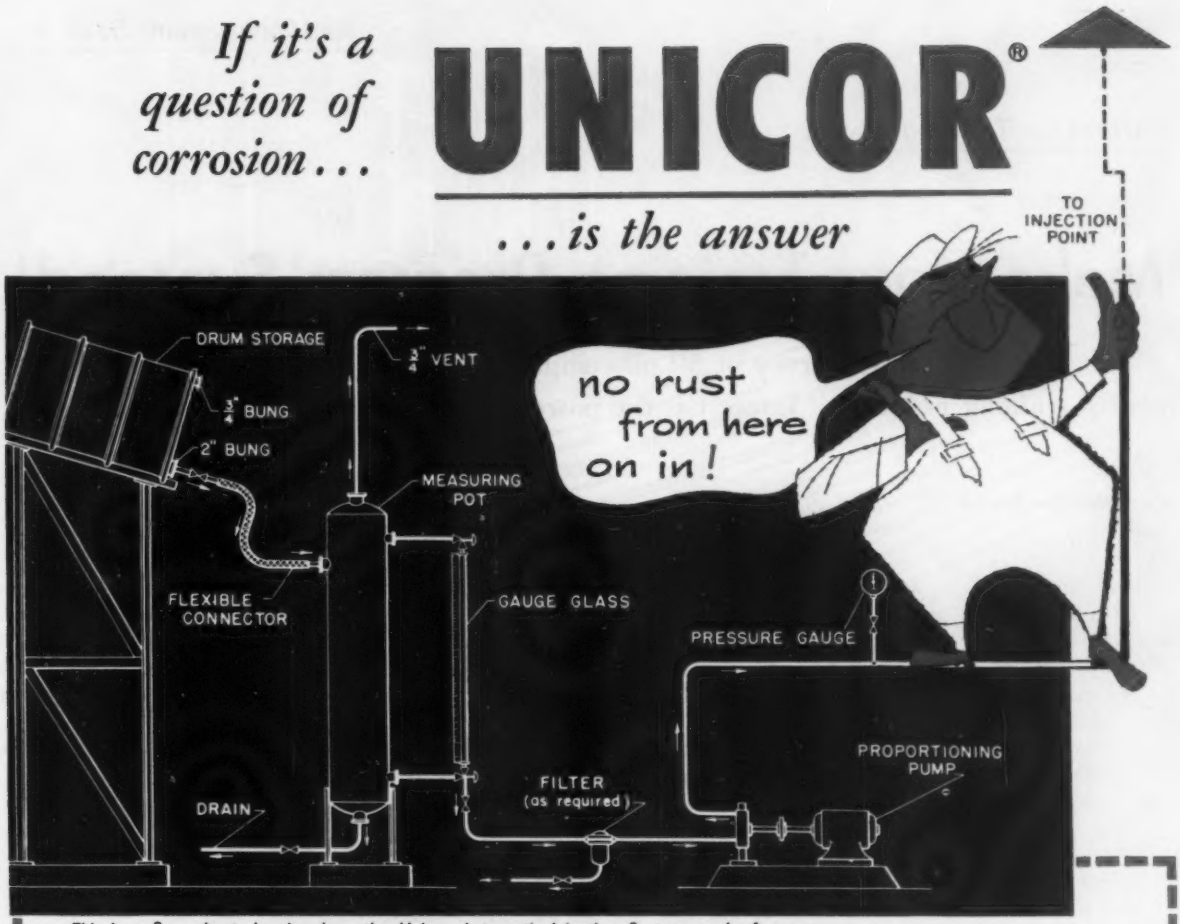
J.H.H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street, New York 54, N. Y.

If it's a question of corrosion...

UNICOR®

...is the answer



This is a flow chart showing how the Unicor Automatic Injection System works for you.

Question: *How can we eliminate serious filter fouling in blending tank caused by formation of highly peptized iron rust during processing?*

Answer: UOP's Unicor corrosion inhibitor solved this problem for a large southern refiner not long ago. Before Unicor application, a yard-square panel of the tank interior was sandblasted down to bare metal to test Unicor's effectiveness. After several months of injection in the rundown line, this test panel was completely free of corrosion, the remainder of tank interior was free of filter-fouling rust.

Question: *Is addition of water necessary?*

Answer: No. Unicor is oil soluble. It also prevents rusting caused by unavoidably entrained or dissolved moisture.

Question: *Should Unicor be injected only in the rundown line?*

Answer: Unicor can be injected at any point in your process. The refiner mentioned above shifted the Unicor injection point from the rundown line to his crude fractionator overhead and in catalytic gasoline from the main column overhead receiver. This extended Unicor's protection to heat exchangers, condensers and towers between new injection points and blending tank. Unicor inhibits corrosion in all your processing equipment from the point of injection on . . . even to consumer equipment.

Question: *How much does Unicor cost?*

Answer: About $0.001 or a tenth of a cent per bbl. of product in normal application.

Let us send you samples of

UNICOR

for testing in your own laboratories.

UOP®

PRODUCTS DEPARTMENT

UNIVERSAL OIL PRODUCTS COMPANY

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Pattern for Training—Part 2

Make Your Training Program Succeed!

This recent survey of 50 oil companies offers all the ingredients for a successful training program. "Interest is the power that makes training machinery run."

Carl Mullins White
Tulsa

THE PURPOSE of any training effort is to effect certain attitude and skill changes in some or all of a company's personnel.

The extent to which these changes are created will be determined by management's basic concepts of training. These concepts include the extent to which management believes in training and how much it is willing to spend to create desired changes in personnel.

After the proper concepts have been established, the next step is to decide which training projects are worth the cost—and whether the company is prepared to handle such training efficiently.

In determining the training program most worth the cost, three important factors must be considered: The trainee must be the center of the training process; the whole man must be trained, not just the special skills of the job; interest must be the power that makes the training machinery run.

These factors can be reduced to a formula—NI equals A. Where N is the number of responses, I is the average intensity of the responses, and A the amount of learning.

A trainee will learn what he wants to learn. The importance he gives to any skill or knowledge in his own scheme of values determines how fast he will learn it. Therefore, a training program should by all means include helping the employe to see that certain goals are of common interest to himself and his company. He should also be instructed in the most efficient ways to learn and to approach these goals.

The successful beginning—and completion—of a training program will be determined by the way in which training leaders answer four questions:

1. What are the most pressing training needs?
2. What are the means and methods best suited to satisfying training needs?
3. Are the training efforts going to be effective through the help of adequate evaluation and follow-up?
4. How can the program be improved?

Determine Most Urgent Needs. Before deciding what to teach, the training leader must find out the *existing* attitude, knowledge or degree of skill, then determine the *desired* attitude, knowledge or degree of skill. The difference between the two must then be analyzed so that the difference may be reduced by training. Following are ways the training leader can seek out the existing and desired situations:

- Testing.
- Performance records or studies.
- Formal surveys (questionnaires, polls, analyses).
- Informal surveys.
- Various combinations of the above.

It should always be kept in mind that a training project will be effective only when the trainee needs the training and knows he needs the training. Interest is one of the foundation stones of training.

Select the Best Means and Methods. The means and methods of executing a training project include courses or subjects, instructors, teaching methods and materials. Each of these factors is discussed below:

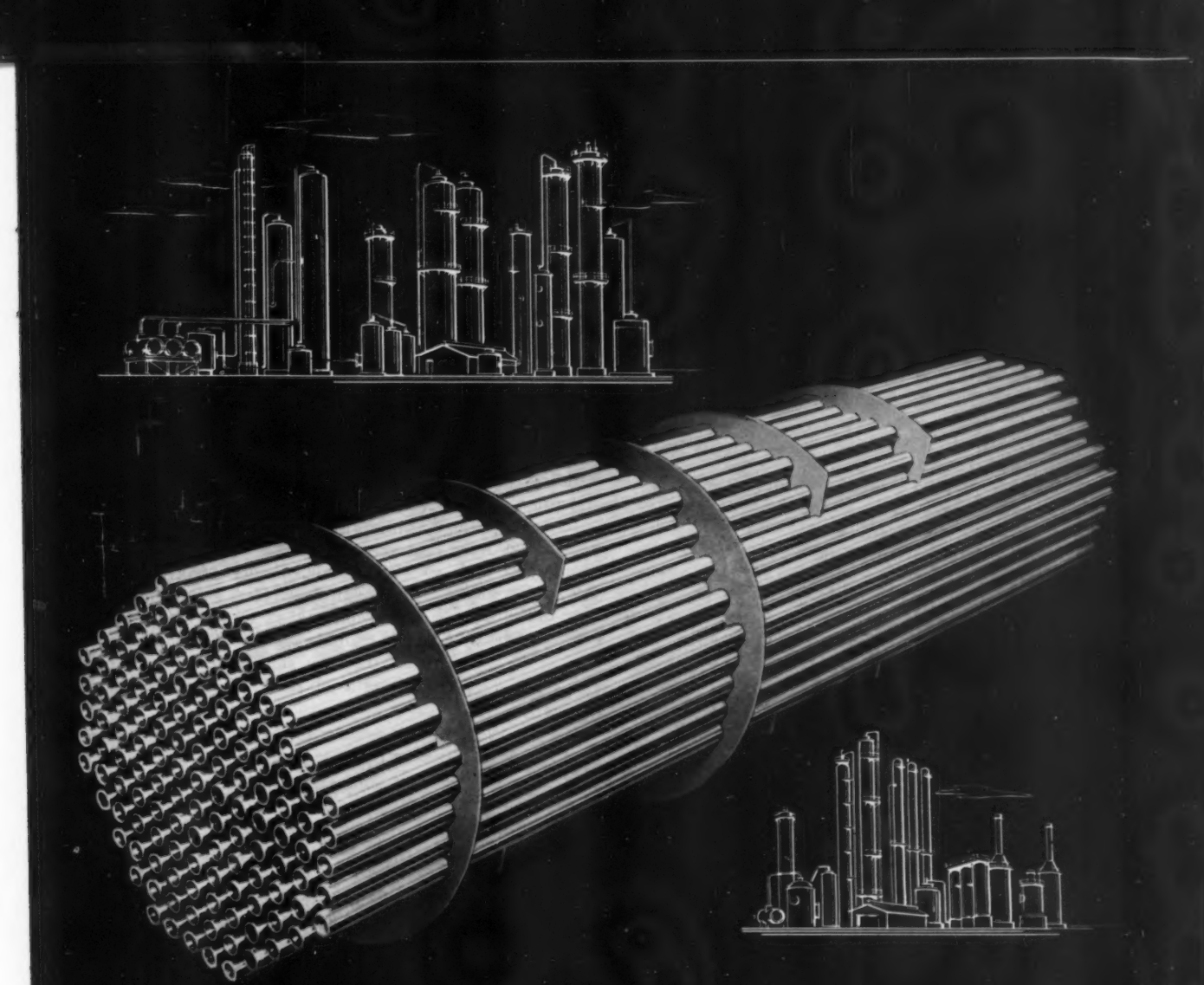
Courses or Subjects. Subject matter should be divided into:

1. Job Know-How.
   - Equipment and its use.
   - Job skill.
   - Technical and scientific training.
2. Human Relations.
   - Human relations for workers.
   - Supervisor training.
   - Executive development.
3. Policies and Procedures.
   - Policy and procedure manuals.
   - Interdepartmental forms and exchanges.
   - Induction and orientation.
   - Re-orientation.
4. Safety.
5. General.

And to these one should be added which is interrelated with all five of the above—Communication. Each of these six has some claim on the interests of all company personnel.

Job know-how is the most commonly taught subject. It is probably the most important. It commands the interest of the trainee because he feels that it contributes to many of his needs. The supervisor and the training specialist should exercise vigilance to see that material covered fills genuine needs. Otherwise it will be wasteful and frustrating.

Job know-how is most commonly taught on the job. But, whenever suf-



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Used in oil preheaters and heat exchangers at major refineries, B&W ERW Tubing is made to ASTM and ASME specifications. It must pass rigid inspection and testing standards in manufacture. Its value has been proved in such heat transfer applications as boilers, condensers, preheaters, economizers, evaporators, and refrigeration equipment.

A call to Mr. Tubes, your nearby B&W Tube representative, will bring you economical recommendations plus quick deliveries. Write for Bulletin 412. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

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Seamless and welded tubular products, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels.

ficient information and sufficient employes can be combined, there are advantages to using a classroom. Training may possibly be done more thoroughly, and it can be accomplished without damage to or shut-down of equipment.

Human relations is not only a subject, it is a concept. It affects and is affected (for better or for worse) by all training. While supervisor and executive development include other training, such as job skills, procedures, and safety, human relations is the most important factor. Human relations should not be thought of as solely for management, however. Individual employes can learn to be better adjusted humans, better cooperators, and more effective co-workers. And human relations training frequently uncovers men with leadership potential.

Policies and procedures are often a part of supervisor training. Supervisors teach it as part of induction, orientation, and job skill training. The Procedure department holds occasional conferences when new manuals are distributed.

Induction orientation is the best form of policies and procedures training, because it comes to the person who most keenly feels his need, the new employe.

Safety is one of the oldest and best recognized types of formal training in the petroleum industry. It has been conducted as separate safety meetings, as a part of supervisor training, or as a part of job skill training.

We can determine training needs by accident records. Happier ways are testing, formal and informal surveys. Other indicators are new equipment, new employes, and transferees.

General training justifies itself on certain assumptions, such as:

- We must bring out the facts in order to protect our government and our economic system against hostile mis-information.
- Industry has excellent means for promulgating sound information.
- Any contribution to the cultural improvement of employes brings long range returns in better employer-employe relationships.
- Better educated employes make better customers, better workers, and better public relations representatives.
- Much valuable general training never gets to some employes through public schools and that industry should give it.

Over half of America's larger oil companies consider these assumptions valid for they offer at least some kind of general training.

When a company inaugurates a general training project, it should ask itself: What courses will the employe recognize as closely tied to his needs?

Communication training includes the various forms of writing, speaking and reading. All forms of training rely heavily on accurate facile communication. The conference probably leans more heavily on communication skills than any other. Communication is the conveyor belt of business.

Instructors. Instructors are divided roughly into three classes:

1. Line supervisor.
2. Outside agency or college.
3. Special company instructor, including:
   - Training supervisor or other training specialist.
   - A line employe designated by his supervisor at the job level.
   - A representative of a staff organization other than the Training Section.

The line supervisor is the backbone of training. He often does the bulk of it. At least he is responsible for the output and the welfare of his employes. It is often advisable to use staff representatives because of their knowledge of whatever technical subjects are being studied, i.e., procedures, safety, hydraulics, or costs.

Outside agencies are more limited as to amount of training, but can supply a helpful boost. Universities offer short courses in executive or supervisory development and in electronics, instruments, and other technical subjects. Some companies give monetary assistance to employes enrolled in evening classes, correspondence courses, half-day work-school, and full time day courses. The API has sponsored technical courses, and some manufacturers offer to their customers' employes short courses on how to use or operate the product.

The training specialist or training supervisor should be the best qualified training planner and conductor in your company. He should have a professional education in psychology, course building, and instruction methods. While the line supervisor is the backbone, the training specialist is the creative mind and spark. He must have a knowledge of training principles, be able to understand employes' wants, formulate training plans, and express himself fluently in speech and writing. With all of this, he must have the knack of getting others to put forth their best efforts. If your company does not have such a man, the alternative is to utilize a university professor or similar consultant to train and assist your instructors.

Who shall conduct a particular training project? Here an enlightened management rises to the support of good training practice. Rank, custom, and tradition step aside in favor of getting a job done. The decisive factors are:

- Benefits to the trainee.
- Benefits to the instructor.
- Long range benefits to the company from developing a number of good instructors.

The short range and the long range values should be carefully weighed in selecting the instructor or combination of instructors for each course.

When practicable, it is most often better to let the training specialist train the supervisors and the staff representatives, and let them carry the main burden of instruction. Obviously one man cannot do all the training.

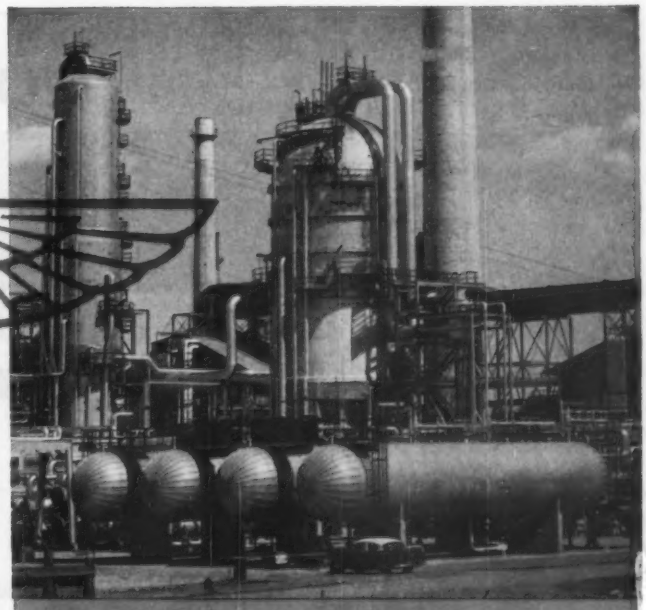
Methods of Instruction. The same principles apply in the selection of training methods. Interest is the propelling force of training. You can develop interest by helping the employe relate his wants to the matter to be learned.

The use of a gun and a whip have been known to create learning interest, but this is an expensive, not to mention unethical, training method. Some better means include: Apprenticeship, lecture, demonstration, case study, problem solving, role playing, brain storming, and conference, directive, permissive, and sectionalized.

Materials. Some of the items to consider are:

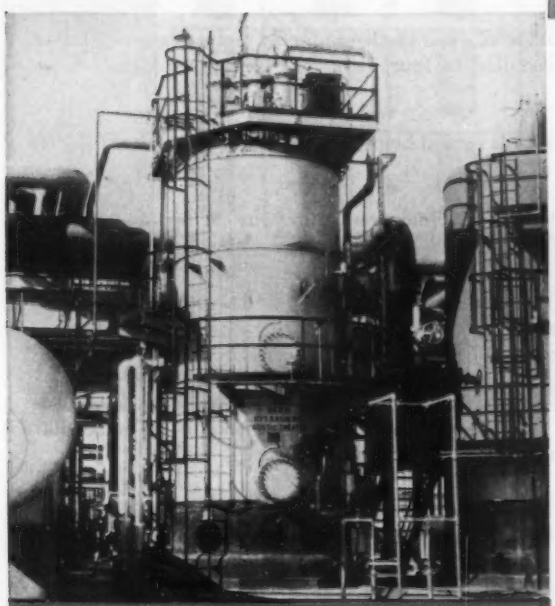
- Classrooms suited to the training you want to conduct.
- Subscriptions to professional train-

again at ***TIDEWATER***



The Petreco Desalter in the foreground of the above photo was designed to desalt extremely salty crude to a very low salt content.

PETRECO ELECTRIC DESALTING



Two-stage Petreco Electrofiner used to caustic-treat and water-wash a heavy gasoline stream. Note the compactness of the unit and the small space it occupies.

AND PETRECO ELECTROFINING *were specified*

At Tidewater Oil Company's new Delaware Refinery the emphasis was definitely on *the best.* The equipment and processes used were specified with one primary objective—to create the finest, most modern refinery in the world.

Petreco feels that the specification of Petreco Electric Desalters for crude charge purification, and Petreco Electrofining for heavy gasoline caustic treating, is particularly significant.

Like other leading refiners all over the world, when Tidewater wanted the best, they specified Petreco.

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A DIVISION OF PETROLITE CORPORATION

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Specialized Electric Petroleum Treating

DESALTING • DEHYDRATING • CAUSTIC WASHING • ACID TREATING • DOCTOR TREATING • SWEETENING • NAPHTHENIC ACID REMOVAL • SEDIMENT REMOVAL

ing magazines and memberships in training and management societies.

- Training library and files.
- Training aids.

Training aids include: Machines and parts. Work specimens. Sound recorder. Printed matter. Blackboards. Charts, pictures, diagrams. Picture projectors for transparent and opaque material. Mechanical trainers—animated panels, synthetic trainers.

Mechanical trainers are expensive. But properly used they may effect economies. They may prevent use and breakage of costly machines.

Sometimes a better job can be done with cleverly chosen training aids than would have been done with others costing many times as much money.

Keep in mind the following principles: Use as great a variety as practicable, the student will remember better. Use the combination best adapted to your particular problem. Make the learner the center—employ the equipment that he likes and can learn to use or understand.

Evaluate and Follow Up. Evaluation is a never ending struggle. It is accomplished by progress records, formal and informal survey, and testing. All these together should tell us whether our training is meeting employes' needs. All levels of management and the training staff should cooperate to see that, whenever practicable, the employe:

1. Uses his new knowledge and skills.
2. Advances as openings occur for which he has qualified himself.
3. Continues to learn and grow in his company career.

Keep Improving. Training needs change as conditions change. To keep abreast of the times requires continuing research and study. In the final analysis, success of your company's training activities will probably depend to a large extent on the calibre of your training supervisor and the cooperation given him by management and workers.

The irreplaceable ingredient of successful training is interest. Interest is the feeling of the trainee that the training is satisfying his wants.

Training is living—with encouragement. # #

If Oil Could Speak

If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

But, oil can't speak—you can. You, as an individual, can win many new friends for the oil industry if you will pass the true facts on to your non-oil industry friends.

Here are some of those true facts. They are being presented for one purpose: To keep you posted on your industry, so you can tell the story oil is unable to relate.

Read these facts. You will find them informative—and interesting.

"If Oil Could Speak" it would tell the American public:

- Efficient, oil-powered diesels are saving the railroads 700 million dollars a year, according to one railroad industry spokesman.

* * *

- Swimming pools made of glass cloth-reinforced polyester resin, an oil product, can be installed in four days for less than the cost of an automobile.

* * *

- Average cost of all wells drilled below 15,000 feet runs about $617,000 per well.

* * *

- A single tankship load of gasoline would run your car for five hundred years.

* * *

- Net income of other industries have averaged more than the oil industry in four out of nine years (1946-54). For the 9-year average, the profits as a percent of net worth of the oil companies exceeded other industries by only one percentage point. In view of the high risks in oil production, it is not unreasonable to expect that the rate of return on the cost of successful properties should be somewhat greater than on investments involving less risk.

* * *

- Although the oil industry earnings have not been out of line with earnings in other industries, the requirements for heavy reinvestment has prevented distribution of earnings to shareholders in the same proportions as other industries.

  The Department of Commerce reports that for the five years 1944-47, industrial corporations paid out in dividends about 41 percent of their net income, while larger oil companies paid out slightly more than 35 percent for the same period. In 1954, the corresponding figures were 52.9 percent for manufacturing companies and 42.7 percent for oil companies.

* * *

- Out of millions of acres leased in the search for oil annually, only 5 to 10 percent prove productive.

* * *

- Out of 250,000 wells drilled in the U. S. during the past five years, nearly 38 percent have been dry holes. This means the production from the average well has to carry the cost of two-thirds of a dry hole in addition to its own costs.

EACH DAY ANOTHER COMPANY TAKES THE LEAD WITH PACE

Wherever engineers assemble, the name PACE has become known as the signature for the latest developments in the art of Analog Computing. The industry has confidence in EAI's PACE Analog Computing Equipment, because it has a proven record, in actual operating hours, of unbeatable accuracy, unmatched speed, and complete dependability. Pictured above are the PACE Analog Computing Systems 16-31R and 16-131R. Write for full details on PACE Equipment and on time rental at EAI's Computation Centers in Princeton, N. J., Los Angeles, Calif., and Brussels, Belgium. Please address all inquiries to: Electronic Associates, Inc., Dept. PR-8, Long Branch, N. J.

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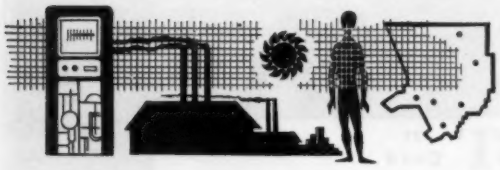
What's Happening . . .

. . . in the Industry



No smog from new plants as . . .

Los Angeles Turns to Industrial Zoning

New industry will be placed in areas where wind will quickly dissipate contaminants.

EVERY FOUR YEARS a population increase the equivalent of a city the size of Pittsburgh is added to burgeoning Los Angeles County.

To prevent this growth from adding to the already man-sized air pollution problem, officials have begun to design a planning and zoning program that will permit the location of new industries and other potential sources of air pollution in areas where they will least contribute to the smog problem.

Air Pollution Control Officer Smith Griswold stated recently that the development of these plans "is a top priority project of the district and one for which nearly $200,000 has been appropriated for the next 12 months."

Although the District already requires the installation of air pollution control equipment on all new industrial devices constructed within Los Angeles County, Griswold points out that "control methods are seldom perfect, and there will always be some loss.

"If industrial air contaminants are controlled to an efficiency of 90 percent, there is still 10 percent that escapes. As industry continues to grow this small percentage becomes larger and larger in actual tonnage, until, when industry has increased tenfold, it equals the total being emitted before any controls were installed."

Oil industry plants in Los Angeles County, in the past nine years, have spent more than $27 million on this fight for the control and elimination of air pollution. This includes $24 million spent in the elimination of 600 tons daily of sulfur dioxide and 700 tons daily of hydrocarbons. In addition, over $3 million has been spent equipping 500 large gasoline storage tanks with floating roofs and vapor control equipment, and in reduction of vapor losses from other sources.

This new zoning project will involve a detailed analysis of wind movements and contaminant concentrations in all areas of Los Angeles County. This will enable new industries to be located in areas where contaminants can be dispersed quickly before they accumulate in doses strong enough to cause air pollution problems. The actual data are collected from 72 individual weather stations and 16 air monitoring facilities.

Every two weeks recording charts, which indicate the speed and direction of winds at all hours of the day, are removed from the weather stations by District technicians.

Information collected from each of these stations is added to data on contaminant concentrations collected from the District's air monitoring instruments and is fed into an electronic computer. This computer, now leased at an annual cost of $65,000, has permitted the uraveling of mil-

HOW INDUSTRY HAS BEEN CONTROLLED

PETROLEUM REFINERIES

More than $24 million has been spent by this industry to eliminate 600 tons of sulfur dioxide, 700 tons of hydrocarbons per day.

IRON AND STEEL

Foundries, furnaces, and mills control 24 tons of dust and fumes that formerly were released to the air.

OPEN BURNING

55 open burning dumps have been abolished in Los Angeles County. All open burning has been halted.

NON-FERROUS METALS

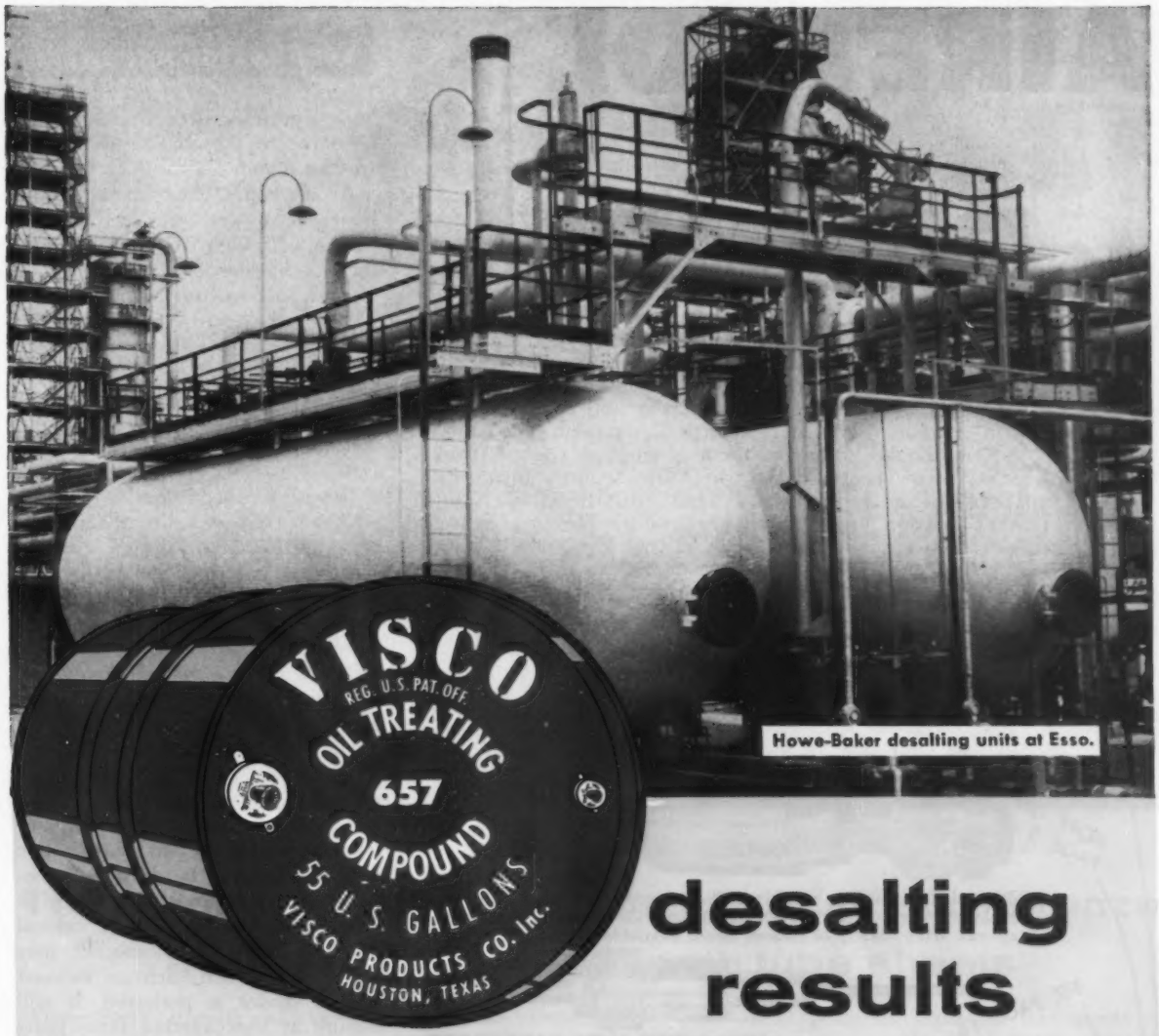
Foundries and smelters for brass, aluminum, zinc, lead, and other non-ferrous metals have installed controls that capture 80 tons of dust and fumes.

HYDROCARBON VAPORS

Over $3 million has been expended to seal 500 large gasoline storage tanks with floating roofs and vapor controls. Other sources of vapor loss also have been controlled.

ALL INDUSTRY

More than 1500 tons of air polluting contaminants are kept from the atmosphere each day by industrial controls throughout the Basin.



Howe-Baker desalting units at Esso.

desalting results

. . . a foregone conclusion at Esso's Bayway Refinery

The modern equipment shown above is one of the recent additions to the Esso Standard Oil Company Refinery at Linden, New Jersey.

With equipment such as this, plus the familiar blue barrels of Visco, outstanding desalting results are a foregone conclusion.

Visco, in either electrical or salt settling equipment, still provides the consistently efficient — and economical — chemical solution to the problem of greater throughput and lower corrosion costs.

Specific information on your particular desalting needs is readily available through your Visco Representative, or contact Visco direct.

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Visco® CONSISTENTLY EFFICIENT OIL INDUSTRY CHEMICALS

AIRETOOL MEANS RESULTS

... results you can *measure* in lower operating costs, reduced down-time, greater efficiency and higher production. Plant engineers and maintenance chiefs the nation over *know* that installation, repair, removal and replacement of tubular equipment is completed faster, easier and at far less cost with Airetool Tube Maintenance Equipment. They know that Airetool Equipment handles easy, is rugged, packs plenty of power and speed, won't break down during use. There's no doubt about it . . . insist on AIRETOOL Equipment for your tube maintenance program. See your nearest Airetool Representative today . . . or write AIRETOOL MANUFACTURING COMPANY, Springfield, Ohio, for free illustrated literature and information.

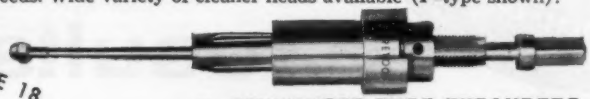
DESCRIBED ON PAGE 15

CONDENSER CLEANERS
Outside mounted, direct or gear driven. Powerful, fast, lightweight (11 lbs.). Cleans lightly scaled or completely plugged tubes to 1". Built in flushing system cools drill, removes chips.

MORE ON PAGE 5

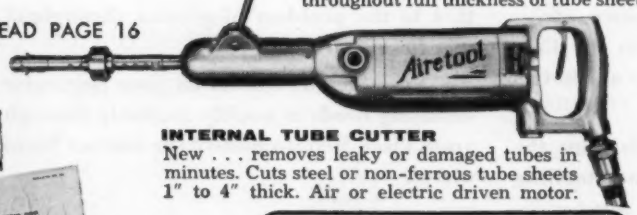
TUBE CLEANERS
Rugged, fast cutting, quickly and thoroughly removes hardest scale and deposit. Air driven motors in wide range of sizes and speeds. Wide variety of cleaner heads available (P-type shown).

SEE PAGE 18



CONDENSER TUBE EXPANDERS
Parallel rolling—self feeding—Airetool Tube Expanders roll right, accurate tube joints with maximum bond, uniform expansion and tightness throughout full thickness of tube sheet.

READ PAGE 16



INTERNAL TUBE CUTTER
New . . . removes leaky or damaged tubes in minutes. Cuts steel or non-ferrous tube sheets 1" to 4" thick. Air or electric driven motor.

Write for illustrated Airetool Bulletin No. 60, showing complete line of Airetool Tube Maintenance equipment plus Airetool Specialty tools . . . Airetool's new, light-weight, air-motor grinders . . . and Airetool's Automatic Expansion Control System.

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REPRESENTATIVES in principal cities of U. S. A., Canada, Mexico, South America, England, Europe, Puerto Rico, Japan, Hawaii.
EUROPEAN PLANT: Vlaardingen, The Netherlands
CANADIAN PLANT: 37 Spalding Drive, Brantford, Ontario

What's Happening . . .

lions of separate items of information produced by the air monitoring and weather stations.

At the end of each computer run punched "answer cards" indicate the path of each air parcel moving across the Los Angeles Basin. Coupled with further analysis, this information indicates the degree to which a pollution source in a specific area effects air contamination levels in other parts of the county.

At the present time, however, fuel oil burning steam power plants still continue to be a prime problem. To cope with these emissions, a Joint Research council on Power Plant Emissions has been formed, and is spending more than $2 million on research studies aimed at the elimination of air pollution problems.

When Los Angeles County reaches the point where industry emissions are being effectively controlled, and are kept that way through the present zoning plan, the single largest source of pollutants then will be the exhaust from automobiles.

At this stage it is unknown how soon it will be before an effective auto exhaust can be devised. Intensive research is underway, but it is believed that it will be a critical problem for at least another four years. Also, when such an exhaust control device is perfected, it will require at least another three years to put it into operation.

Future efforts during the next 12 months, those of interest to the oil industry, and which involve much research and investigation, will include:

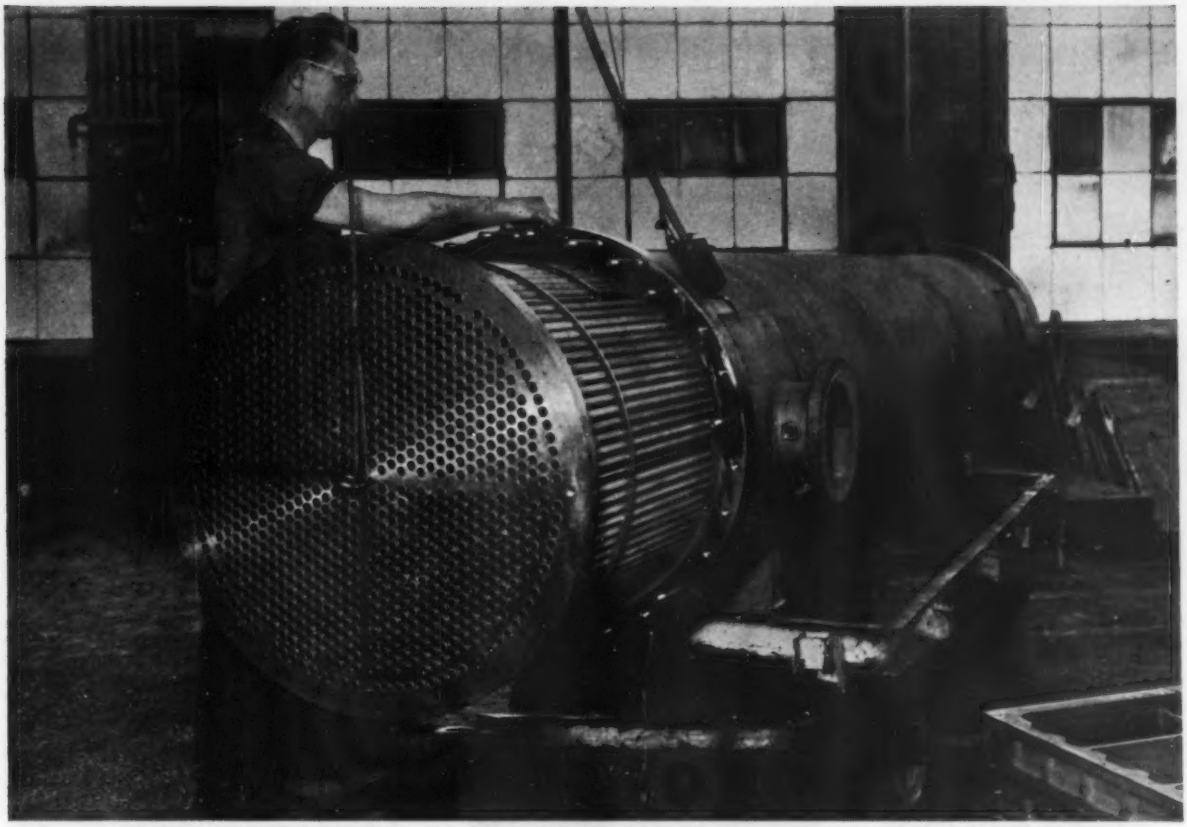
1 Evaluation on the road and in laboratories, of exhaust control devices developed by outside agencies.

2 Catalyst testing and evaluation to determine effectiveness in removing of smog-forming organic compounds from motor exhausts.

3 A contract research project concerned with the efficiency of various catalysts in removing nitric oxides from motor exhausts.

4 Analysis of auto exhaust constituents to study specific properties and quantities and effects of contaminants emitted under typical driving conditions.

5 An intensive investigation into the effects of fuel composition on the



Tube bundle partially removed from shell of General Electric heat exchanger. Fixed-end tube sheet is Ambraloy-917, one of The American Brass Company's aluminum-bronze alloys. Tube sheet is 36⅜" diameter, 2" thick.

Thick, rolled circles of Anaconda Aluminum Bronze available for high-strength tube sheets

Where superior strength and corrosion resistance are required in heat-exchange applications, the use of *rolled* circles of Ambraloy-917 for the tube sheets offers appreciable savings in material cost compared to circles produced by the forging process. The American Brass Company can furnish Ambraloy-917 in rolled circles up to 5" thick, maximum diameters are governed by thickness.

Anaconda sheets, plates and circles are available in a wide range of alloys and sizes for heat-exchange service in marine and stationary-steam power plants, oil refineries and other process industries. Produced by the rolling process, they are commercially flat, accurate in dimensions and are free from the surface imperfections and porosity often prevalent in cast plates. The American Brass Company makes plates for condenser tube sheets of copper and several copper alloys in rectangular sizes up to 156 inches in width and weights up to 15,000 pounds for any shape that can be cut from such sheet. The maximum standard limits for circles are 160 inches in diameter and 11,000 pounds in weight. Half-circles can be produced up to 13,000 pounds in weight.

Special jobs. When specifications call for extremely large plates for special applications, The American Brass Company will gladly cooperate in the solution of such problems. For further information on Anaconda Condenser Tubes or Tube Sheets write: The American Brass Company, Waterbury 20, Conn.

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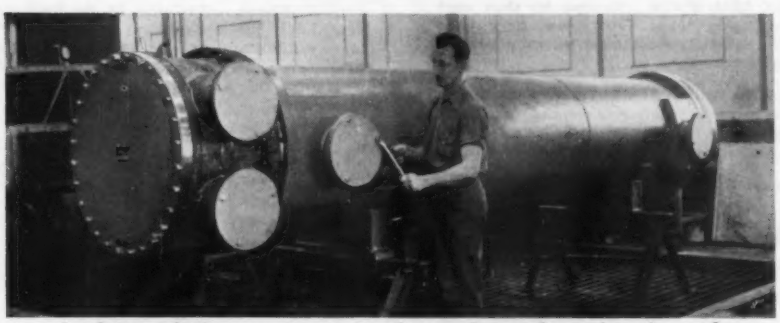

Completed General Electric water-to-water heat exchanger for cooling the condensate recirculated through the hydrogen coolers of a 427,500-kva cross-compound turbine-generator unit. Water box cover is also Ambraloy-917, 36½" diameter and 2⅜" thick.

ANACONDA®

TUBES AND PLATES FOR CONDENSERS AND HEAT EXCHANGERS

Made by

The American Brass Company

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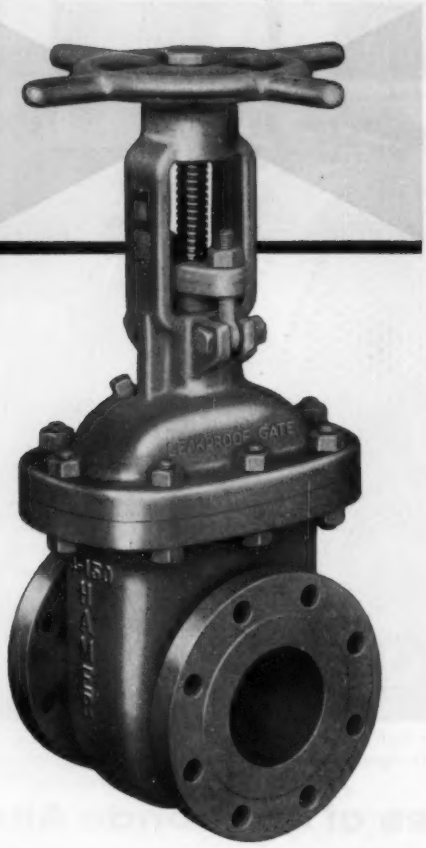
Introducing the new

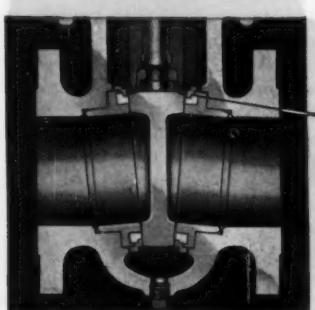
HAMER
Leakproof
GATE
VALVE



Impenetrable Shut-off Upstream —Downstream

This new Hamer Gate Valve incorporates a double sealing action design that's both absolute and foolproof. In addition to the precision metal to metal fit of the wedge, the Hamer Gate Valve incorporates two Teflon* seal rings which compress dead tight against the wedge. Thoroughly proven under the most rugged field condition tests, the Hamer Gate Valve with its positive shut-off both upstream and downstream, eliminates the need for a double block and bleed in piping installations.

Hamer Gate Valves incorporate a new high standard of valve production. Stainless steel valve seats are welded-in for accurate fit. Locking rings are of corrosion resistant stainless steel. And precision finish on critical parts assure a smooth operating valve even after years of hard service. Write today for literature. See for yourself why Hamer Gate Valves are truly **a valve without equal.**



Double Sealing Action forms Impassable Shut-off

TEFLON SEAL RINGS... Renown for their inert characteristics, these Teflon seal rings have amazing durability even under the most adverse of service conditions.

PRECISION FINISHED GUIDES... Wedge guides are machined to exacting tolerances. Eliminates chatter and wear caused by line pulsations, accurately centralizes the wedge between the seats.

*RTM DUPONT

Send for Gate Valve Catalog

Hamer *VALVES INC.*
P. O. Box 1851
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Representatives throughout the World

What's Happening . . .

emission of smog forming materials from auto exhausts.

Just what will it cost—this over-all effort for all industrial and domestic control? For the first nine years says Air Pollution Control District, total cost was $72,770,000; over the next five years, approximately $300 million more will be spent in licking the problem.

SRI Gets New Smog Data

Chemists at Stanford Research Institute, working on the problem of smog control, have come up with data which will provide a greater understanding of smog formation and a better knowledge of the chemistry of the upper atmosphere. In order to account for the presence of oxidents which react with hydrocarbons in the atmosphere to form smog, SRI chemists investigated the formation of atomic oxygen by the photolysis of nitrogen dioxide. Photolysis equipment has been built to provide a controllable source of small, known concentrations of atomic oxygen. A technique is now available, therefore, for conveniently measuring the absolute reaction rates of atomic oxygen with hydrocarbons and, presumably, with other compounds. The equipment employs a continuous flow, stirred tank reactor so that rate constants can be obtained directly without integration of the rate equations. The reactor is a 50-liter flask covered with crinkled aluminum foil to give uniform radiation. Four windows are located symmetrically around the circumference with mercury arcs and optical filters outside each.

O.K. Shale Plant Funds

Senate has approved a compromise Interior Department appropriations bill containing $135,000 for maintenance of oil shale oil plant and facilities at Rifle, Colo. This came after Chairman Hayden (D-Ariz.) of Senate Appropriations Committee said bill will not allow dismantling of plant. Bill now goes to White House.

Senators Carroll (D-Colo.) and Allott (R-Colo.) demanded assurances from Hayden that the bill would not bar further work at plant by allowing demobilization.

Atomic Energy and Oil

A highlight of the Fifth World Petroleum Congress, scheduled to be held in New York City's Coliseum in 1959, will be a symposium on the exploratory use of atomic energy for new methods of processing oil and for creating new oil products.

This was announced following a meeting last month of the permanent council of the World Petroleum Congress in Frankfurt, Germany. Chairman of the council, which is represented by 11 countries, is Eger V. Murphree, president of Esso Research and Engineering Co.

New Texaco Fuel Inhibitor

The Texas Co. has developed a petrochemical additive to bring about a reduction of the difficulties resulting from the

For more data on advertised products, use Readers' Service Cards, last page.

Memo: to all process engineers—

Why Tolerate Liquid Carry-Over?

...when METEX Hi-Thruput Mist Eliminators can deliver 100% efficiency!

● Whether it's on a vertical tube evaporator, a packed column, knock-out drum or a vacuum pipe still, there's no necessity, *today*, to permit poor liquid-vapor separation to pull product quality and profits down. With Metex, you have a unit that's *different*. Hundreds of thousands of openings and wire surfaces, so combined as to baffle uprising gas-liquid streams in multiples of thousands of physical separating contacts, can and *do effect complete gas-liquid-contaminant separation.*

No other unit delivers more efficiency, offers longer life or less maintenance. Used and specified by hundreds of process engineers, Metex Hi-Thruput Mist Eliminators are the standard of excellence wherever efficient entrainment separation is important to good production and profits.

• Write for Bulletin ME-6

METEX QUALITY PRODUCTS

• metal textile corporation

roselle, new jersey

Representatives in principal cities throughout the world.

7-072

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

presence of fine rust particles in aviation gasoline and aircraft turbine fuels.

The new blending component, Texaco Aircraft Fuel Inhibitor, is being made available to refiners following six years of extensive field testing in refinery storage equipment, pipe lines, and tankers.

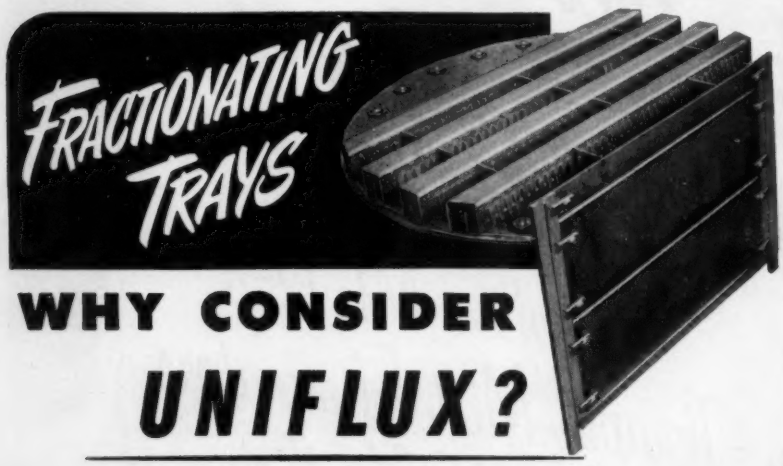
L. C. Kemp, Jr., vice president of The Texas Co.'s Petrochemical department, said that the inhibiting action of the new corrosion preventive is polar in nature. It does not react with the metal surfaces it contacts. The material is wholly petroleum derived; there are no metallic elements in its composition.

More Refinery Cutbacks

Esso Standard Oil Co. cuts its July refinery runs 23,000 bpd below June rate "to bring inventories into better balance with demand." Company's cutback comes on top of 21,500 bpd reduction below rate originally planned for June.

Slack demand early this summer caused Esso to change its plans early on operating rate, spokesman said. In May, company at first slated 11,000 bpd increase in operation for June, but settled on rate 10,500 below May.

Socony Mobil has cut its refinery runs by 31,000 bpd, or about 7.5 percent from previously planned schedules. Its 45,000 bpd East St. Louis plant has been closed since June as the result of strike.



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FOR LOWER COST? . . . . . YES!
(25% to 50% Lower)

FOR COMPARABLE CAPACITY? . . . . YES!
(Equal or Better Than Conventional Designs)

FOR HIGHER EFFICIENCY? . . . . . YES!
(Closer Approach to Equilibrium)

FOR MAXIMUM FLEXIBILITY? . . . . YES!
(Wide Operating Range)

FOR MINIMUM MAINTENANCE? . . . YES!
(Simplified Installation, Self-Cleaning Characteristics)

LET US REVIEW YOUR SPECIFIC APPLICATIONS

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MISCO FABRICATORS, INC.
Designers, Builders, Fabricators of Heat Resisting Alloy and Stainless Steel Equipment

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Shale Land Suits Filed

Suit has been filed in the Denver U. S. District Court challenging a Union Oil Co. of California claim to 1920 acres of oil shale land in Garfield County, Colo.

The civil suit was filed by Denver attorneys Fred A. Deering, Jr., and Raymond C. Johnson in behalf of 13 residents of Virginia. It asks court judgment denying any past, present or future claims by Union to three sections of land north of Grand Valley.

Virginians claimed they won the "Stanley" or "Mary Ann," placer mining claims originally filed in their interest October 1, 1919.

Suit alleges that Union is now "wrongfully and unlawfully" in possession of lands because sites were not open for exploration nor were they part of public domain when Union published its notice of application for U. S. patent on lands last April 12.

Three contested sections are a few miles north of Grand Valley near Parachute Creek where Union has its oil shale demonstration plant.

NGAA Changes Meeting

The scheduling of a regional meeting in the Northern Hotel, Billings, Mont., for Wednesday, September 25, by the Natural Gasoline Association of America, made necessary a change in date for the regional meeting at Oklahoma City. The latter was originally scheduled for Friday, September 27, at the Skirvin Hotel but has now been shifted to Friday, January 31, 1958.

The Billings meeting is being held at the request of NGAA members of the Rocky Mountain and Canadian areas and it is expected that approximately 200 operating men from these regions will attend.

European Company Formed

The British Petroleum Co.'s German associate, BP Benzin-und Petroleum G.m.b.H., and Farbenfabriken Bayer of Leverkusen will form a joint company for the manufacture of petroleum chemical products. BP and Bayer will each have a 50 percent participation in this company. The name of the new company and the address of its offices will be announced at a later date.

The site of the production units, of which the first is already built, is adjacent to the Bayer plant at Dormagen, near Cologne. The plan calls for an investment of about $56 million with 300,000 tons a year of petroleum feedstock being required for the plant's cracking units. This will be supplied from a new BP refinery to be built in the Ruhr area. The plant will produce organic semi-finished products.

More Small Refiner JP-4

Navy officials have told Senator Smathers (D-Fla.) they will try to close the gap between the 8 million barrels of JP-4 the military buys from small refiners each year and the 25 million barrels which industry sources say can be supplied.

Assistant Navy Secretary Bantz and Admiral Claxton, chief of naval material, have advised Smathers' Senate Small Business subcommittee on procurement, that they will study recommendations made by Florida Senator and by small refiners to see if this buying can be increased.

Naval officials warned, however, that

For more data on advertised products, use Readers' Service Cards, last page.

DU PONT *Petroleum Chemicals* NEWS

Number 78 in a Series of Bulletins for the Petroleum Industry

AUGUST 1957

Three major projects insure still better TEL delivery, service

NEW ASSISTANT TO THE TECHNICAL MANAGER

ANTON O. MELBY is assistant to the Technical Manager of the Du Pont Petroleum Chemicals Division. His duties involve the coordination of both technical service and new product development.

He came to this post from the Du Pont Petroleum Laboratory where he was in charge of the gasoline additives division. Among the projects of this group was the development of Dimethyl Formamide (DMF) as a gasoline anti-icing agent. Prior to this he was supervisor of the Petroleum Laboratory group working on combustion and scavenging.

In connection with his work at the Laboratory, Mr. Melby published a number of technical papers on combustion reactions and the effect of additives. Among them are papers titled: "An Investigation of Pre-ignition in Engines," "The Effects of Fuel Additives on the Precombustion Reactions of n-Heptane."

Following three years of service in the Army during World War II, Mr. Melby earned a B.S. degree in chemical engineering at the University of Wisconsin. He then continued his studies, at the University of Michigan, receiving an M.S. degree there in 1949. He joined the Du Pont Petroleum Laboratory staff in 1950.

He is a member of the Society of Automotive Engineers and the Petroleum Division of the American Chemical Society.

Du Pont adds important facilities in first half of '57

The new TEL storage and delivery terminal at Beaumont, Texas, is the latest addition to the rapidly growing list of Du Pont facilities for serving the company's TEL customers.

Earlier this year the TEL tank-ship, *MV Petrochem*, which was commissioned two months ago, became another major addition to Du Pont's tetraethyl lead distribution setup. The Petroleum Chemicals Division's new TEL manufacturing plant has been completed at Antioch, California. It is the only TEL plant located in the important West Coast refining area.

THE RECENTLY COMPLETED Du Pont TEL terminal at Beaumont, Texas. It contains complete modern facilities for the storage and handling of TEL, and rapid dispatch of loaded tank cars.

The new Beaumont terminal, which represents an important delivery convenience for Gulf Coast refiners, will be supplied from the Du Pont TEL plant at the Chambers Works, Deepwater, N. J., by the tank-ship.

The terminal has ample storage capacity to meet the expanding TEL requirements of the Gulf Coast refineries. It contains complete TEL handling facilities. A rail siding on the property means that a number of TEL tank cars can be pre-loaded there and be ready for immediate dispatch to any refinery in the area. A dock and special unloading equipment for the new tank-ship are also important segments of the operation.

This means that the new Beaumont terminal is equipped to provide refiners with the same TEL availability and fast delivery service as Du Pont's manufacturing plants.

Unique ship

The *MV Petrochem* is a two-cargo vessel. Designed primarily to move bulk

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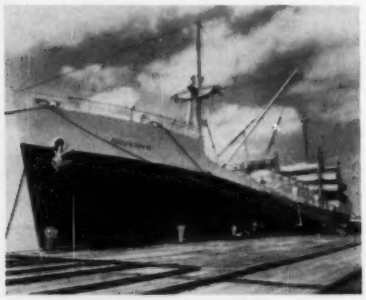
OVER

DUPONT *Petroleum Chemicals* NEWS

CONTINUED *Major Projects*

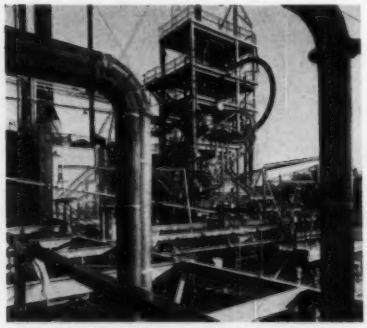
shipments of TEL south, she is equipped also for transporting ethyl chloride and ethylene dichloride on the northbound sailing.



THIS 6,000-TON SHIP, *MV Petrochem,* **is the first overwater chemical carrier to transport TEL compound in bulk.**

New West Coast Plant

DuPont's new TEL manufacturing plant at Antioch, California, was constructed to meet the needs of the fast-growing West Coast oil industry. The new plant makes possible fast, short-distance shipments of California-made TEL to all West Coast refineries.



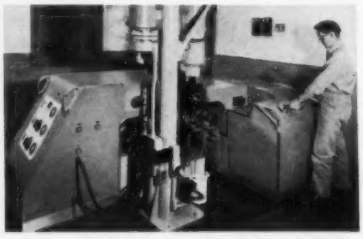
THIS NEW DuPont TEL plant in California incorporates the most modern, continuous process TEL manufacturing facilities in the world.

These three major expansions will increase even more the efficiency of the nationwide network of DuPont TEL facilities – which, as previously, includes also conveniently located rail sidings with loaded tank cars in 14 major refining areas across the country, plus the five Petroleum Chemicals Division regional laboratories and the twelve sales and service offices.

The many technical, marketing, research, safety, and operational services offered by DuPont . . . the most complete line of petroleum additives offered by any supplier . . . the new facilities–these together assure you of getting the most out of your additives program.

New facts about knock uncovered by spectrometric study at Du Pont Petroleum Laboratory

A versatile spectrometer geared to a single-cylinder engine is being used at the DuPont Petroleum Laboratory to study the reactions responsible for the cool, blue, and intense blue flames which are obtained in an engine combustion chamber as it is motored under increasingly severe operating conditions.



HERE IS the unique spectrometer used by the DuPont Petroleum Laboratory for studying the chemistry of knock and the fundamentals of combustion. The operator is shown adjusting the amplifier for recording. Part of the single-cylinder engine can be seen in the center of the picture.

As a result of these studies, spectral evidence has been found by the Laboratory indicating that these reactions progressively involve more extensive degradation and oxidation of the fuel. Hydrocarbon decomposition and formation of carbonyl compounds are involved in reactions emitting cool flames. And further oxidation of carbonyl compounds is especially important in reactions giving blue flames.

Free radical reactions

The free radical reactions occurring under intense blue flame conditions easily lead to auto-ignition and knock. But tetraethyl lead apparently interferes with this series of reactions by slowing down carbonyl decomposition reactions under blue flame conditions, possibly by deactivating free radical intermediates.

A detailed account of this study was recently published. When writing for a copy, refer to the title, "Spectrometric Investigations of n-Heptane Preflame Reactions in a Motored Engine."

New book gives detailed information about Du Pont Fuel Oil Additive No. 2

DuPont FOA-2 is probably the most versatile of all fuel oil additives. Its wide range of applications includes home heating, residual, and diesel fuels of all grades . . . for railroad, marine, truck, tractor and stationary engines. It has also been found to be highly effective for cleaning heat exchangers and sludge-laden tanks.

To help refiners benefit fully from FOA-2 in all these applications, we have just published a comprehensive 24-page book about it. All the basic information you will need is included –composition and properties, use concentrations, handling and additive methods, performance testing, and a discussion of the quality of FOA-2 in all its applications. The book is fully illustrated with photographs, charts and diagrams; a copy is yours for the asking. Just write our nearest sales office.

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Pittsburgh 22–1 Gateway Center . . . ATlantic 1-2933
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OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-4967

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small refiners may not want to supply a large percentage of military's JP-4 requirement. Smathers had stated earlier he hopes all JP-4 could eventually be set aside for small refiners.

Sohio Takes Legal Action Against OCAW Local

Standard of Ohio is taking legal actions against seven Oil, Chemical & Atomic Workers locals after some three months of fruitless bargaining.

Company has filed unfair labor practice charges against the locals with Cleveland regional office of NLRB, alleging, among other things, that OCAW is trying to force bargaining on a company-wide basis.

"We signed a two-year contract last year with each of our units represented by the OCAW," company spokesman said, "and the contracts allow the union to re-open at the end of the first year to negotiate on wages only."

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation of the Illinois Institute of Technology, 35 West 33rd Street, Chicago 16, Ill., has great need for the chemicals listed below. If anyone has one or more, even if only in one gram quantity, please inform the Registry.

N-Benzyl-n-heptadecylamine
cis-9,10-Dihydroxy decalin
trans-9,10-Dihydroxy decalin
2,2,3,3,4,4-Hexamethylpentane
Vinyl fluoride
trans-1,2-Dibromethylene
Methionic acid
1,4,5,8-Tetrabromonapththalene
Thiofluorenone
Thioacetophenone
Spiro (4.4) nonane
1,2,3,4,5,6,7,8-Octahydroanthracene
1-Methylcyclopentanol
2-Heptylnonanoic acid
Di-m-tolyl-1-naphthylphosphate
Bromomethyl methyl ether
N-Dodecyl benzamide
9-Anthraceneacetic acid
1,1-Dichlorocyclopropane
m-Hydroxyphenylacetic acid

New Shell Process Free

Shell Development Co. has announced that a patented process to prevent hydrogen blistering of steel refinery equipment has been made available to industry through a royalty free license.

Shell said the grant has been made in consideration of the splendid assistance received from other branches of industry and as a contribution to industrial safety.

It appears that blistering occurs when hydrogen sulfide reacts with steel, forming atomic hydrogen which then penetrates the steel, collects in laminations and slag inclusions and combines to form molecular hydrogen. This molecular hydrogen accumulates there developing sufficient internal gas pressure to crack and blister the steel.

Shell's process inhibits the penetration of hydrogen into steel and thus prevents blistering. The patented process calls for the injection of small amounts of air into processing equipment, where conditions are conducive to hydrogen attack. Ammonia is added to maintain proper alkalinity.

What's Happening . . .

— Awards —

Achieving a record of more than three million man hours worked without a disabling accident, members of the Ohio Oil Co.'s Refining department have earned the highest recognition obtainable from the National Safety Council. A pennant symbolizing the Council's Award of Honor was run up the flag pole at the company's Robinson, Ill., refinery. The award was presented for an accident-free period between Nov. 2, 1954 and Jan. 1, 1957, totaling 3,195,377 man hours.

Another National Safety Council award went to the Bakersfield Refining division of Douglas Oil Co. of California. A Certificate of Commendation was presented in recognition of the division's safety record of 421,000 man-hours worked between February, 1954, and December, 1956, without a disabling injury to any of its 85 employees.

It is one of 12 Certificate awards by the National Safety Council to U. S. refineries in the "less than 500 employees" category.

Changing Times

Oil companies are **counterattacking proposed revision** of Internal Revenue Code which bans **tax deductions for lobbying purposes.** Oil public relations men are not arguing that point, but they **object to the hazy wording** which could be construed to bring good-will and public-education efforts under definition of lobbying.

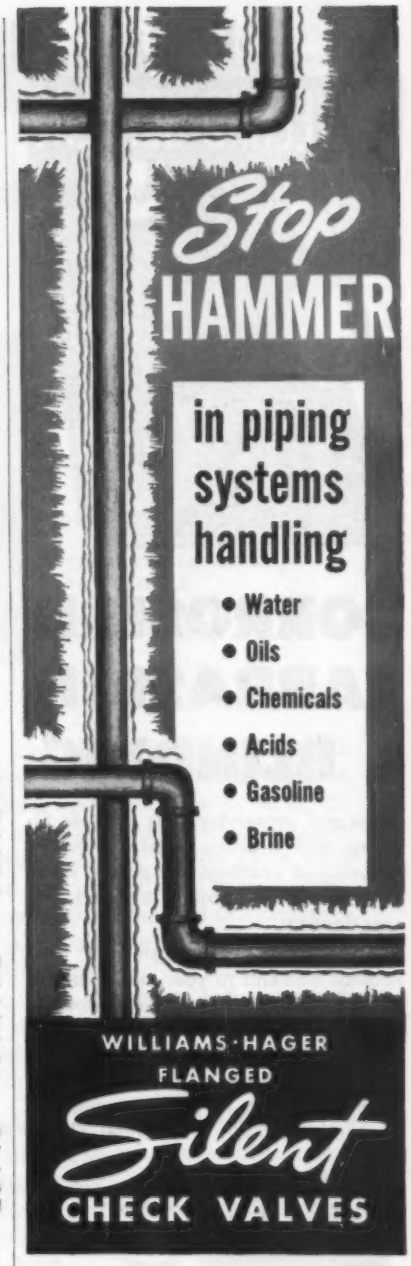
FTC charged Union Carbide violated anti-merger provisions of the Clayton act when it acquiring one of its major customers, Visking Corp. Charges say merger may lessen competition or produce monopoly in distribution of polyethylene resin and film.

Congress has authorized **3000 reprints of report, "International Oil Cartel,"** for use by Senate antitrust subcommittee. Subcommittee aide has said additional copies were sought because so **many requests had been made for document.**

New York District Court has finally dismissed Justice Department's 5-year-old multi-million dollar suit charging Caltex group with "overcharging" for Marshall Plan oil from Middle East. **Two similar suits still pending, though**—against Jersey-Standard group, and Socony Mobil group.

Sales by domestic refiners during first quarter of 1957 totaled $7.31 billion, up 18.6 percent from same period last year and up 8.3 percent from fourth quarter 1956. **Profits after taxes totaled** $806 million, up 23.8 percent from 1956 period but 2.5 percent below fourth quarter 1956.

Five majors have made proposals to Illinois requirements that **oil companies must finance construction of twin-service-station, overpass-restaurant combinations** if they want service stations on new toll



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What's Happening. . .

roads. Eight projected service areas on three toll roads call for a **service station on each side of the road** with a restaurant bridging the roads and linking the two stations. State Toll Highway Commission hasn't money to build the facilities so **is looking to the companies for that.**

Magnolia Petroleum may enter the petrochemical field. Company has set up special **committee to investigate feasibility** of manufacturing petrochemical products near its Beaumont, Texas refinery.

U. S. Army and Interior Department have agreed for transfer of **200 acres of Sand Island in Honolulu harbor to territory of Hawaii for possible leasing as a refinery site.** Army has agreed to lease major portion of island, but is still balking on certain small portions.

Argentina's state owned petroleum company has **invited U. S. oil concerns to participate in a special exposition** Dec. 1 through March 31, 1958 commemorating the first Argentine oil discovery. **Interested companies should write** Yacimientos Petroliferos Fiscales, Av. R. Saenz Pena 777, Buenos Aires, Argentina.

D-X Sunray is using **employee support to push sales** of new D-X Boron "gas" by giving prizes to employes who introduce it to most customers . . . worldwide **demand for jet fuel** now exceeds that for aviation gasoline . . . daily average **production of natural gas liquids in April** was 34.5 million gallons—up 7 percent from April last year . . . OCAW has made public a letter to President Eisenhower declaring, **"we deny oil price increases have been justified by labor costs". . .**

Changes In Ownership

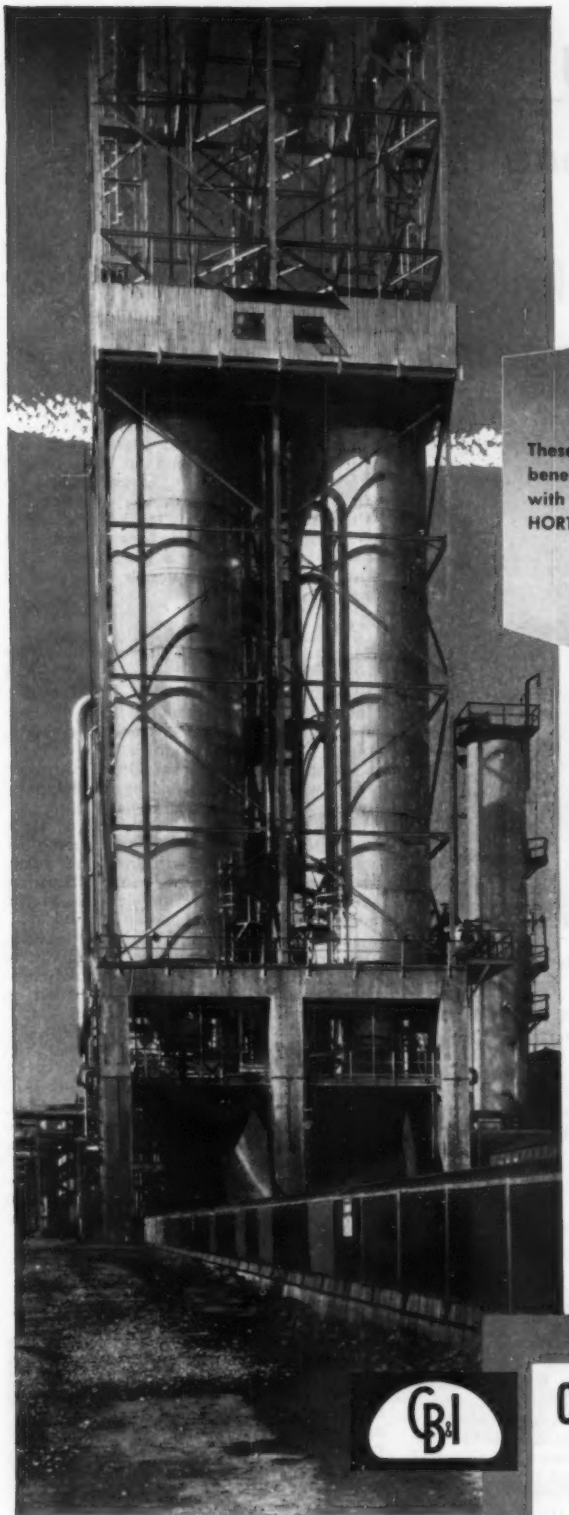
Dow Chemical Co. and Dobeckmun Co. directors have approved a proposal for the merger of the two companies. Agreement is subject to approval of stockholders of Dobeckmun who will vote at a special meeting to be held late in August. If approved, Dobeckmun will continue to operate under present officers, and firm will be known as Dobeckmun Co., a division of Dow Chemical Co.

Union Oil Co. of California has merged two of its subsidiaries, **Brea Chemicals Inc.,** operating in the petrochemical field, and **R. T. Collier Corp.,** operating in the carbon and allied fields. New corporation will be known as Collier Carbon and Chemical Corp.

Texas Eastern Transmission will acquire **La Gloria Oil & Gas Co.,** Corpus Christi, if stockholders and Security and Exchange Commission the $70 million stock transaction proposal.

MEETINGS CALENDAR

AUG.	
19–21	Cryogenis Engineering Conference, host will be National Bureau of Standards in Boulder, Boulder, Colo.
28–30	Analysis Instrument Committee's International Symposium on Gas Chromatography, Kellogg Center, East Lansing, Mich.
SEPT.	
3– 5	Pacific Coast Gas Association Convention, Sherman Hotel, Chicago.
5– 6	API Oil Information Committee, Meeting, Broadmoor Hotel, Colorado Springs.
8–13	American Chemical Society, 132nd National Meeting, New York City.
9–11	American Institute of Electrical Engineers, Petroleum Industry Conference, Sheraton Hotel, Philadelphia.
9–13	Instrument Society of America, 12th Annual Instrument Automation Conference and Exhibit, Cleveland Auditorium, Cleveland.
11–13	National Petroleum Association, 55th Annual Meeting, Traymore Hotel, Atlantic City, N.J.
15–18	American Institute of Chemical Engineers, Lord Baltimore Hotel, Baltimore.
22–25	The 12th Annual Petroleum Mechanical Engineering Conference, ASME, Mayo Hotel, Tulsa.
23–25	American Society of Mechanical Engineers, Fall Meeting, Statler Hotel, Hartford, Conn.
26–27	Western Petroleum Refiners Association, Rocky Mountain Regional Technical-Industrial Relations Meeting, Henning Hotel, Casper, Wyoming.
27	Natural Gasoline Association of America, Oklahoma Regional Meeting, Skirvin Hotel, Oklahoma City.
30–Oct. 2	American Oil Chemists' Society, 1957 Fall Meeting, Netherland Plaza Hotel, Cincinnati.
OCT.	
1– 4	National Association of Corrosion Engineers, North Central Region in Sherman Hotel, Chicago; South Central Region in City Auditorium, Oklahoma City.
7– 9	ASLE-ASME Lubrication Conference, Chateau Frontenac, Quebec, Canada.
7–11	American Institute of Electrical Engineers, 1957 Fall General Meeting, Morrison Hotel, Chicago.
9–11	Fourth Annual Symposium of High Vacuum Technology, Hotel Somerset, Boston.
10–11	California Natural Gasoline Association, 32nd Annual Fall Meeting, Huntington-Sheraton Hotel, Pasadena, California.
10–12	ASME, Fuels-AIME Conference, Chateau Frontenac, Quebec City, Que.
18	American Institute of Chemical Engineers, South Texas Section, 12th Annual Technical Meeting, Moody Convention Center, Galveston.
22–24	National Association of Corrosion Engineers, Seventh Annual Western Regional Conference, U.S. Grant Hotel, San Diego.
24–25	Western Petroleum Refiners Assn., Regional Technical-Industrial Relations Meeting, Rufus Garrett Hotel, El Dorado, Ark.
25	Natural Gasoline Association of America, Southern Regional, Washington-Youree Hotel and Captain Shreve Hotel, Shreveport, La.
28–29	Annual Meeting, National Lubricating Grease Institute, Edgewater Beach Hotel, Chicago.
28–31	American Nuclear Society, Second Winter Meeting, Henry Hudson Hotel, New York
NOV.	
6– 8	Society of Automotive Engineers, National Fuels and Lubricants Meeting, Hotel Statler, Cleveland.
11–14	American Petroleum Institute 37th Annual Meeting, Conrad Hilton and Palmer House, Chicago.
12–14	National Association of Corrosion Engineers, Northeast Region Fall Meeting, Penn-Sheraton Hotel, Pittsburgh.
22	Natural Gasoline Association of America, Panhandle Plains Regional Meeting, Herring Hotel, Amarillo.



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For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . *Among Men* in the Industry

Walker Takes CNGA Helm As Directors Meet in Los Angeles

Bill Walker assumed his duties as newly elected president of the California Natural Gasoline Association last month at the annual CNGA board of directors meeting held in the Biltmore Hotel, Los Angeles.

Outgoing President R. W. Todd, Pacific Lighting Gas Supply Co., turned over the gavel to Walker who is the division mechanical engineer of the Western Gulf Oil Co. Since joining CNGA in 1944 he has been chairman of such important committees as the education committee, fall meeting committee and the advisory committee.

H. J. Maxwell, manager of the Natural Gas and Gasoline department, Standard Oil Co. of California, was presented as the newly elected vice-president. He will also serve as chairman of the advisory committee.

New directors elected to serve a two year term were: George Ehrhart, Ehrhart & Associates, Inc.; M. L. Fort, Pacific Lighting Gas Supply Co.; C. D. Gard, retired; R. W. Heath, Signal Oil & Gas Co.; J. C. Herron, Shell Oil Co.; R. J. Hull, Gas Processing Associates; Wm. A. Kirk, California Southern Oil Co.; Warren H. Kraft, Honolulu Oil Corp.; Grove Lawrence, Southern California Gas Co.; L. V. Leonard, Shell Oil Co.; A. C. Lyles, General Petroleum Corp.; S. F. Magor, The Superior Oil Co.; P. S. Magruder, General Petroleum Corp.; Guy T. Martin, Guy T. Martin & Co., Inc.; J. A. Smith, The Texas Co.; R. W. Todd, Pacific Lighting Gas Supply Co.; Geo. T. Tennison, Shell Oil Co.; K. C. Vaughan, Union Oil Co. of California; R. J. Williamson, The Cooper-Bessemer Corp.; and L. M. Windle, Richfield Oil Corp.

The new president appointed the following men as standing committee chairmen for 1957-1958: Award—M. L. Arnold, Richfield Oil Corp.; Entertainment—John Donnell, C. F. Braun & Co.; Fall Meeting—R. E. Loeck, California Research Corp.; Finance & Budget—K. C. Vaughan, Union Oil Co. of California; Membership—E. Vernon Frost, Frost Engineering Service Co.; Program—Frank E. Sesler, Ehrhart & Associates, Inc.; Technical—Harvey Menard, Signal Oil & Gas Co.; Technical Advisory—C. L. Hutchings, Tidewater Oil Co.

E. R. Millett, Jr. was reappointed as Secretary-Treasurer.

Bill Walker

Dr. Vladimir Haensel, Universal Oil Products Co. director of refining research, has been awarded the honorary degree of Doctor of Science by Northwestern University.

Dr. Haensel received a Ph.D. degree in organic chemistry at Northwestern in 1941 after receiving a B.S. degree in engineering at the same university and an M.S. degree in chemical engineering at Massachusetts Institute of Technology. His first association with UOP was as a summer employe in 1932 while attending school; he was employed as a full time research chemist in 1937.

He was named Universal's coordinator of cracking research in 1945, and in 1955 became director of refining research.

Juergen J. Bloess, Baytown, Texas, and **Mark A. Halepeska,** Corpus Christi, Texas, have been appointed to the engineering staff of Great Northern Oil Co.

Bloess, formerly associated with Humble Oil & Refining Co., Baytown, as chemical engineer has been assigned duties as process engineer in Great Northern's Technical Service department. He is a graduate of the Missouri School of Mines and a member of AIChE.

Before joining Great Northern as field maintenance engineer in the Maintenance department, Halepeska attended Rice Institute, Houston, where he received his B.S. degree in mechanical engineering. A member of the ASME, he is also affiliated with the Engineering Society.

Ralph James, Jr., has been promoted to supervising engineer, and **E. A. Clarke** to senior chemical engineer in the Engineering division at Humble Oil & Refining Co.'s Baytown, Texas, refinery.

James directs the activities of a group that is responsible for coordinating Humble's engineering standards program, the scheduling for engineering design work and the operation of the engineering library. He holds a B.S. degree from the University of Texas and an M.S. degree from the University of Houston, both in mechanical engineering.

Clarke is engaged in the process design of major projects planned for construction in the refinery. He is a graduate of Rice Institute with a B.S. degree in electrical engineering.

H. Harold Bible has been named vice president and assistant general manager of the Lion Oil Co. division of Monsanto Chemical Co. Bible, who has been director of manufacturing since December, 1955, joined Lion at El Dorado in March, 1942, as synthesis supervisor at Ozark ordnance works which was operated by the company for the Army Ordnance Department.

He held the posts of technical assistant to the vice president of manufacturing for one year, technical assistant nine years, and assistant manager of manufacturing three years, before being elevated to the position of director of manufacturing.

A native of Lawton, Okla., Bible graduated from the University of Oklahoma in 1938 with a B.S. degree in chemical engineering. Prior to employment by Lion he was with Humble Oil and Refining Co.

Herman G. Gunter, formerly vice president in charge of refining for Suntide Refining Co. at Corpus Christi, Texas, was elected vice president of Commerce Oil Refining Corp. in charge of construction and operations.

Prior to his position with Suntide Refining Co., Gunter spent more than 20 years with the Standard Oil Co. of New Jersey and various of its subsidiaries.

Eugene S. Martin is the new superintendent of Shell Chemical Corp.'s synthetic rubber plant at Torrance, Calif.

Martin

Martin succeeds **G. S. Williamson,** recently named manager of Shell Chemical's ammonia plant at Shell Point, in the San Francisco Bay area.

Before coming to Torrance in March of 1955 to fill the position of assistant plant superintendent, Martin served as senior technologist of Shell Chemical's manufacturing development department in New York. He joined the Shell Companies

3 FROM 1

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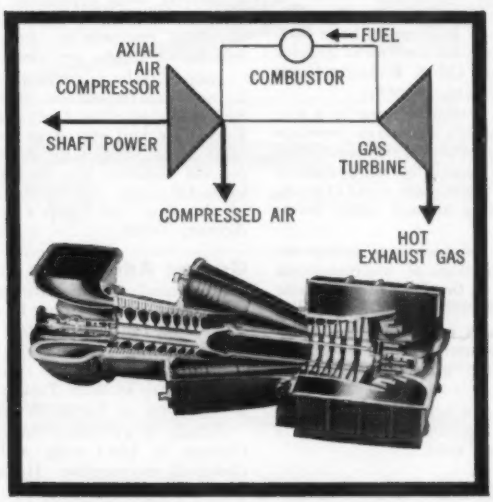
As gasifiers—In a large Southwestern butadiene plant, four Westinghouse gas turbines will soon be operating as gasifiers for the reactivation of the catalyst and each will eliminate the need for a separate prime mover and a separate air compressor.



In addition, smaller line heaters and less fuel will be used because *all* the *Btu's* put into the gas turbine are exhausted to the heaters and process, with the exception of minor radiation and bearing losses.

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Shaft power.....up to 22,500 hp
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Men in the Industry . . .

as a junior technologist at Shell Oil's Wilmington refinery in 1942 after graduating from the University of California with a B.S. degree in petroleum engineering.

Thomas P. Brown and **Walter N. Alexander** have been appointed to the newly created positions of senior vice president of Scientific Design Co., Inc. Brown, a graduate in chemical engineering of Auburn and formerly vice president of Reichhold Chemicals, Inc., had been vice president of new projects for SD. Alexander, a Yale chemical engineering alumnus, was previously director of operational planning and chief design engineer at Linden, N J., for General Aniline and Film Corp., and has been executive vice president of SD Plants, Inc., construction subsidiary of SD.

Promoted to vice presidencies in the company are the following assistant vice presidents: **Henry F. Peters** of engineering; **David Brown** of research and development; and **Philip E. Newman** of European affairs.

Further advancements were made as follows:

Paul S. Monroe, from director of engineering to assistant vice president-director of general engineering; **Dr. Alfred Saffer,** from manager-research and development to assistant vice president-research and development; **Gregory F. Vinci,** from project engineer to director of the operating department; **Russell G. Hill,** from project engineer to technical assistant to the vice president-engineering; **Dr. John H. Lutz,** from project engineer to administrative assistant to the vice president-engineering; **John W. Colton,** to director of process development; **Dr. Robert S. Davis,** to director of engineering development; and **Robert W. Simon,** to assistant to the vice president-European affairs.

Dr. Ernest O. Lawrence, Berkeley, Calif., professor of physics and director of the University of California's radiation laboratory, has been elected a member of the Board of Monsanto Chemical Co.

Winner of the Nobel Prize in physics (1939), Lawrence is a native of Canton, S. D. He holds an A.B. degree from the University of South Dakota, an A.M. degree from the University of Minnesota and a Ph.D. degree from Yale University.

The holder of honorary degrees from 14 universities here and abroad, Lawrence is an Officier de la Legion d'Honneur. Additionally, he has received such awards as the Elliott Cresson Medal of Franklin Institute; the Comstock Prize of National Academy of Sciences; the Hughes Medal of the Royal Society of England; the Duddell Medal of the London Physical Society; the William K. Dunn Award of the American Legion; the Medal for Merit; and the Faraday Medal.

Dr. Warren G. Schlinger has been transferred to Texaco's Port Arthur, Texas, Research Laboratory as a project engineer in fuels research. He was formerly a chemical engineer with Texaco's research laboratory in Montebello, Calif.

He was educated in California, receiving his Ph.D. degree in chemical engineering from the California Institute of Technology in 1949. He remained there to teach chemical engineering for four years prior to joining Texaco at Montebello in 1953.

Dr. J. R. Morris has been transferred to Texaco's Port Arthur, Texas, Research Laboratories as assistant supervisor in chemicals research. He was formerly on the staff of the manager of Research at the Texaco Research Center in Beacon, N. Y.

Dr. Morris received his Ph.D. degree in organic chemistry in 1937 from Indiana University. He joined Texaco in 1939 as a chemist at their Research Center in Beacon. He holds eleven patents chiefly in the field of lubricants, and is a member of the American Chemical Society, Sigma Xi, and Phi Lambda Upsilon.

Bullington

Dreselly

Dudley

Pfennig

L. A. Bullington has been promoted to technical specialist and **R. A. Dreselly, A. R. Dudley** and **R. F. Pfennig** have been named section heads in Technical Service Division at Humble Oil & Refining Company's Baytown, Texas, refinery.

Bullington is at present serving as a section head in Humble's executive development program. His section is responsible for technical activities associated with treating and catalytic hydrogenation operations, and means of abating air and water pollution.

Dreselly heads the technical group responsible for technological improvements and new projects in the field of butadiene production.

Dudley's section is responsible for technical activities associated with the operation of crude distillation and lubricating oil finishing facilities.

Pfennig directs the activities of the section charged with developing new projects in the petrochemical field.

A. S. (Steve) Gilliam has been elected plant manager of Great Nothern Oil Co.'s Pine Bend refinery. Gilliam joined the firm in late 1956. He will continue as plant manager in addition to his new responsibilities as a vice president.

A veteran of petroleum refining experience, Gilliam was an executive of Olin-Mathieson Chemical Corp., prior to joining Great Northern Oil Co. Previously he had served with Shell Oil Co. at their Houston, and Wood River, Ill., plants.

Elmer W. Griscom, manager of Sinclair Refining Co.'s East Chicago refinery, has been promoted to manager of operations in the manufacturing department, New York. **George A. Blaine,** assistant refinery manager, was elevated to manager.

The promotions result from a realignment of manufacturing activities into two new groups—operations and planning. Three divisions of this group which Griscom will head are light oil, asphalt and chemicals, and lube and wax production.

Dr. Robert L. May, formerly an assistant division director at Sinclair's research center in Harvey, Ill., was promoted to assistant manager of lube oil production, New York.

Griscom will be in charge of personnel, labor relations, and coordinated long range planning for the operations group under direction of W. Vaugn Ischie, vice president and general manager of manufacturing.

Dr. Donald S. Taylor has been elected vice president in charge of Research of the United States Borax & Chemical Corp. to succeed G. A. Connell, retired. Dr. Taylor will make his headquarters in the corporation's new $1 million Research Center nearing completion in Anaheim, Calif.

Dr. Taylor holds a Ph.D. from Caltech. He worked for three years for the Shell Development company in Emeryville, Calif., and for four years for DuPont in El Monte. He joined Pacific Coast Borax in 1945 and last July, when Pacific Coast merged with United States Potash to form United States Borax & Chemical Corporation, Dr. Taylor was placed in charge of the combined companies research program.

James E. Harrell, Jr., has joined the staff of Universal Oil Products Co. to represent its products department in technical sales work in the Gulf Coast area. He will also assist refiners in treating, blending, and general refinery problems.

Harrell, who graduated from Rice Institute in 1943 with a B.S. degree in chemical engineering, has had extensive experience in the petroleum refining field.

Immediately prior to joining Universal, he was superintendent of the Suntide Refining Co. plant at Corpus Christi, Texas. Earlier he had served as assistant superintendent of Texas City Refinery, Inc.; was process engineer for the Magnolia Petroleum Co., and worked in the laboratories of the Gulf Oil Corp.'s refinery at Port Arthur, Texas.

George Adams, Des Plaines, Ill., has been named operations assistant to **Harry A. Brown,** vice president in charge of manufacturing for D-X Sunray Oil Co.

In his new position, Adams will assist in the operations of the company's 75,000-bpd refinery at West Tulsa and the 45,000-barrel plant at Sunray Village (Duncan).

Adams graduated from Kansas State College in 1948 with a B.S. degree in chemical engineering. He was with Universal Oil Products Co. for eight years before joining D-X Sunray.

Russell Field, Wylie F. Nance, and **David L. Narver, Jr.,** have been named assistant vice presidents of Holmes & Narver, Inc., Los Angeles firm of engineers and constructors.

Russell Field, who joined the firm in 1954, will be primarily concerned with business development activities. Educated at the University of Kansas, Field served

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The lightweight Rockwood SG-60 WaterFOG Nozzle *eliminates "special" or single-purpose nozzles!* It actually does the work of five nozzles to put out fires faster, safer and more economically.

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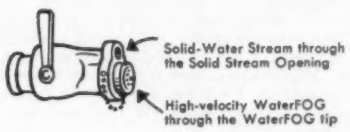

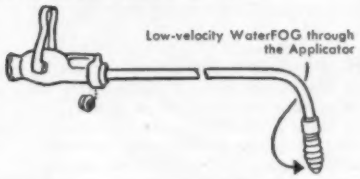

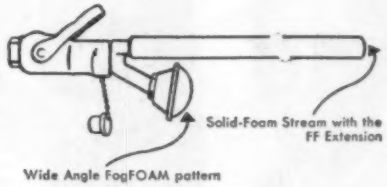

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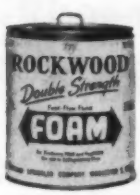
FOAM and "Wet" Eductor with the new FW Metering-Check Valve. Introduces Rockwood FOAM or "Wet" into hose lines, automatically proportioning correct amount of FOAM and "Wet" to water. Also usable wherever one liquid is fed into another on a fixed percentage basis.



Rockwood Double Strength FOAM. Puts out fires in flammable liquids, and in ordinary combustibles, quicker, at lower cost. Three parts FOAM and 97 parts water create a heat-resistant blanket.

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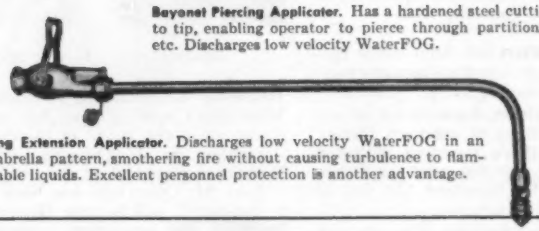

Long Extension Applicator. Discharges low velocity WaterFOG in an umbrella pattern, smothering fire without causing turbulence to flammable liquids. Excellent personnel protection is another advantage.

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Men in the Industry . . .

for five years as manager of commercial services for the AEC at Oak Ridge, Tenn.

W. F. Nance first joined Holmes & Narver only a few months after the company was founded in 1933. At that time, he had already accumulated nearly 20 years of diverse experience in civil engineering following his education at the University of Illinois and Wisconsin University.

David L. Narver, Jr., has held increasingly responsible positions with Holmes & Narver since joining the firm in 1942 following graduation from Stanford University. In his new position he will assist the vice president of engineering and construction.

Thaman

Jones

A. J. Thaman has been named superintendent of oil movements division at Humble Oil & Refining Co.'s Baytown, Texas, refinery. This includes compound and package, oil straining and blending, docks, pumping and gauging, railroad and shipping, and blending departments.

B. D. Jones has been promoted to assistant superintendent, responsible for the administrative and operational functions of pumping and gauging, railroad and shipping, and blending departments.

Thaman joined the Baytown refinery in 1926 as assistant dockmaster, advancing in 1929 to assistant foreman of the pumping and gauging department. He has been assistant superintendent of oil movements since 1947.

Joining the refinery in 1920, Jones has advanced through a number of positions; he has served as assistant foreman of pumping and gauging, dockmaster, and railroad foreman.

D. Glenn Morgan, director of research and development for D-X Sunray Oil Co. has retired from active service after completing 38 years in oil refining.

Morgan joined the old Cosden and Co. refinery in 1919 as a tester in the West Tulsa laboratory. He served as assistant foreman in the processing department and assistant process superintendent through 1921. He became process superintendent in 1922. From 1925 to 1944 he served as assistant general superintendent, general superintendent and manager of the Tulsa refinery. In 1945 Morgan was named general manager of the D-X refinery. In 1949 he became director of research and development, the position he held on retirement.

Morgan is known in the mid-continent refining industry, having served on various American Petroleum Institute fuels and lubricants committees, Western Petroleum Refiners Association technical advisory committee, the American Society for Testing Materials and the Asphalt Institute.

William E. Baston has been named staff engineer, reforming and extraction, of Tidewater Oil Co's new Delaware refinery near Wilmington. Other supervisors include:

John A. Bayalis, section head, business machines and payroll; **Joseph A. Dunphy,** staff engineer, oil dispatching; **William H. Graf,** staff engineer, crude area, and **Charles S. Joanedis,** staff engineer, desulfurizing and hydrogen.

Also, **Charles McCloud,** staff engineer, coking area; **John J. McMahon,** section head, general accounting section; **Frank J. Menton,** staff engineer, alkylation-polymerization; **John Nalesnik,** section head, process accounting section; **Robert E. O'Sullivan,** staff engineer, utilities and sulfur recovery section; and **Joseph H. Schramm,** staff engineer, cracking area.

Also, **Lyle C. Pratt, Bernard E. Woods, Russell S. Pease** and **Louis G. Fuller,** named shift foremen of the crude-coking-cracking areas, and **William F. Limber, Edward F. Naus, Earl J. Borde** and **John J. Scott,** named shift foremen of the alkylation-polymerization-reforming-desulfurizing areas.

W. H. Pinckard has retired as chairman of California Texas Oil Co. after 40 years of service and **W. F. Bramstedt,** president of Caltex since 1950, has been elected to succeed him. **A. J. Singleton,** executive vice president, succeeds Bramstedt as president.

Other Caltex changes include **H. C. Hose** who has been named a director and executive vice president, **H. B. Nicholls,** named senior vice president and **G. R. Ferguson** named a vice president. **R. E. Ludt** was named executive assistant to the chairman of the board.

Graham F. Towers has been named chairman of BP (Canada) Ltd. The company is planning construction of a refinery in the Montreal area. A McGill University graduate, Towers served as governor of the Bank of Canada from 1934 until 1954.

Robert G. Schmidt, a chemical engineer, has been named project manager for the new $4 million plant of Callery Chemical Co. at Lawrence, Kan., E. G. Sanner, president announced.

Sanner also announced the appointment of **Stanley J. Demski** to the post of construction manager for the Lawrence plant.

Schmidt received a B.S. degree in chemical engineering and business administration at Massachusetts Institute of Technology in 1948.

Demski received a B.S. degree in chemical engineering at Pennsylvania State University in 1943. He joined Callery after leaving The Celanese Corporation of America plant at Amcelle, Md.

Robert G. Brown has been made special representative of California Crude Sales Co., Perth Amboy, N. J.

In this new position, Brown's duties will include the handling of sales of foreign crude oils in northern countries of South America, Central America, and the Caribbean areas for this Standard Oil Co. of California operating subsidiary.

Brown has been scheduler of supply and transportation since the establishment of the crude sales organization in 1955. Prior to that time, he was affiliated with The California Oil Co. as supervisor of crude oil supply, general foreman, and designs engineer

Edward J. Healy was elected vice president-construction, of The Kuljian Corp., Philadelphia engineers and constructors. His professional career includes more than 25 years' experience in field and office administration of construction, and general supervision.

Before joining Kuljian, Healy had 13 years of construction management experience with Turner Construction Co., Keystone State Construction Co., and the Pennsylvania Railroad.

A graduate electro-chemical engineer from M.I.T., Healy is a member of ASME and the National Society of Professional Engineers.

Hrand H. Levonian, who previously held this position, has been elected a vice president of the organization.

Fred W. Macfarline, former maintenance supervisor for Great Northern Oil Co., St. Paul, Minn., has joined The Vickers Petroleum Co., Inc. refinery, Potwin, Kan., as chief refinery engineer. He will be in charge of refinery maintenance, both mechanical and engineering along with refinery safety and inspection.

A graduate of the University of Oklahoma with a B.S. degree in civil engineering, Macfarline's former industry associations include Foor Engineering Co., Blaw-Knox Co., Deep Rock Oil Co., and Great Northern.

Vickers has promoted **Raymond S. Gibson** to the newly created post of senior process engineer at the Potwin, refinery. His new responsibilities include the technical operation, results and improvements of all refinery units along with yield and economic calculations, projections and analyses.

A chemical engineering graduate of Kansas State, Gibson has been with Vickers refinery since 1951. He was formerly associated with the Bruce Williams Laboratory, Joplin, Mo. Gibson is mayor of Potwin.

George F. Getty, II, director and vice president of Tidewater Oil Co. and general manager of its Eastern division, has been named a director of Mission Development Co.

Nichols

Osborne

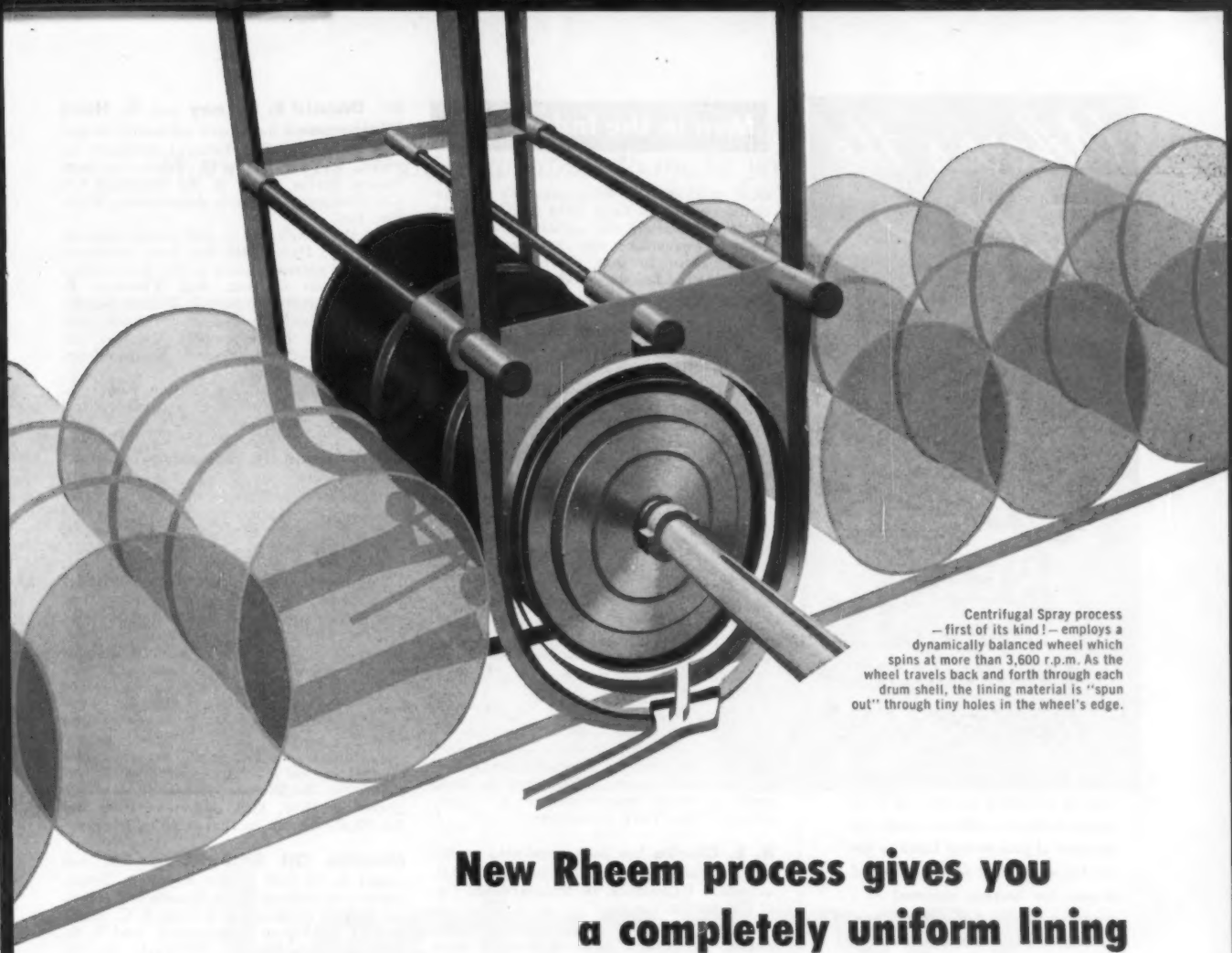
Thomas S. Nichols, president of Olin Mathieson Chemical Corp., has been named chairman of the board of directors.

Stanley de J. Osborne will replace Nichols as president of the corporation.

John M. Olin, who has been chairman of the board, will become chairman of the financial and operating committee, and will continue as chairman of the executive committee.

Nichols has been president of Olin Mathieson since 1954. Before that he had been chairman of the board and president of Mathieson Chemical Corp.

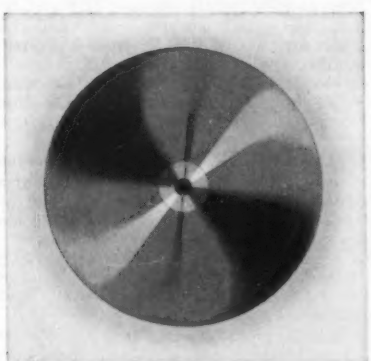
Osborne has been executive vice presi-



Centrifugal Spray process — first of its kind! — employs a dynamically balanced wheel which spins at more than 3,600 r.p.m. As the wheel travels back and forth through each drum shell, the lining material is "spun out" through tiny holes in the wheel's edge.

New Rheem process gives you a completely uniform lining

...drum after drum after drum



New Centrifugal Sprayer spins off a continuous curtain of atomized lining material at a uniform rate.

Uniform lining thickness—controlled to within .1 of a mil
Uniform viscosity of lining materials with lower solvent content
Uniform application:

- Completely automatic · No air used in spray
- Spray travels same distance to coat all surfaces
- No air turbulence, primary air or drum rotation

Uniform curing:

- 3-stage ovens with controlled temperatures
- Controlled air flow by placing drums upright in oven

This new Rheem Centrifugal Spray process is so fully automatic, drum linings can't vary from one drum to the next, one day to the next.

It's a vast improvement over all other lining methods. For it does away with troublesome air turbulence that causes oil, dust and dirt to gum up linings applied by conventional methods.

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Men in the Industry . . .

dent in charge of the company's international operations since 1954 and in March of 1956 assumed the additional responsibility of executive vice president for finance. Prior to that, he had been vice president for finance of Mathieson Chemical Corp.

Nicholas A. Vonneuman has joined the patent and licensing division of Houdry Process Corp.

He comes to the organization from Washington, D. C., where he maintained a general and patent law practice and was also associated with the Italian technical delegation engaged in contracting operations.

Vonneuman was born in Budapest, Hungary, and received his Ph.D. degree in law at the University of Budapest. He also holds a B.A. as well as an M.A. degree in law from George Washington University and is a member of the bar of the District of Columbia. He served three years in the U. S. Army.

James J. Glasco has been appointed manager of the tax department of Socony Mobil Oil Co., Inc.

Joining Socony Mobil in 1922, Glasco has held numerous positions in the accounting and comptroller's departments. In 1951 he became assistant manager of the tax department, a position he held until his recent promotion. He is a graduate of New York University.

R. E. Clarke has been appointed to the newly-created position of manager, Natural Gas Utilization, of Standard Oil Co. of California.

Former manager of the gas organization in the producing department, Clarke will report to O. N. Miller, vice president, natural gas utilization and distribution.

Harry M. Schafer has been appointed manager of supply, a new position at Union Oil Co. of California.

Schafer will be responsible for the purchase of crude oil and petroleum products required to supplement the company's crude oil production in California.

Prior to this appointment Schafer was manager of distribution for Union's extensive Southwest marketing territory.

Howard E. Everson has been appointed chief staff engineer in Diamond Alkali Co.'s Central Engineering department.

Everson joined the Diamond organization in 1951 as a senior chemist in research. He subsequently handled other research assignments until November, 1956, when he was transferred to the Central Engineering department in Cleveland as a senior engineer.

His earlier experience includes three years on the faculty of the University of Cincinnati as an assistant professor of chemistry, and two years in a research capacity with another prominent chemical producer.

A graduate of Western Reserve University with B.A. and M.S. degrees in chemistry, Everson earned his Ph.D. degree in 1948. He belongs to several technical societies and associations, including the American Chemical Society and the Ohio Academy of Science.

Dr. Donald E. Burney and **G. Hans Weisemann** have been advanced to section leaders in the chemical products division, and **Dr. Philip H. Towle** has been named group leader in the Standard Oil Co. (Indiana) research department, Whiting, Ind.

In the development and patent department, Dr. Philip Hill has been advanced to senior patent advisor in the information development division, and **Thomas E. Earle** to patent advisor. **J. Robert Stapleton** has been appointed patent researcher; **Douglas G. Brace,** patent licensing coordinator; and **Raymond F. Maldoon,** technologist.

In the administrative division, Robert E. Pritz has been appointed records control supervisor.

Dr. William H. Schuette, general manager of The Dow Chemical Co.'s Midland division, has been elected to the company's board of directors. He was elevated to the position of Midland division general manager in 1955.

In addition to his responsibilities with Dow, Dr. Schuette is a director of Polychem, Ltd., an operation formed by Dow and Kilachand, Devchand and Co., Ltd., for the production of styron in Bombay, India. He is also responsible for the operations of the company subsidiaries, Bay Refining Corp. and Bay Pipe Line Corp. at Bay City, Mich., and the company's new petrochemical plant under construction near Bay City.

A native of Cleveland, Dr. Schuette studied chemical engineering at Case Institute of Technology, receiving his B.S. degree in 1933, M.S. degree in 1939 and his Ph.D. degree in that field in 1941.

Humble Oil & Refining Co. has added to its staff at the Baytown, Texas, refinery as follows: **W. S. Reaves** to Technical Service division; **T. J. Cox, J. C. Davis** and **M. L. Fly** to Engineering; and **S. A. Thomas** and **W. G. DePierri, Jr.,** to Research and Development.

Reaves holds the B.S. degree in chemical engineering from Alabama Polytechnic Institute; Davis and Fly, B.S. degrees in mechanical engineering from University of Florida and Texas A & M College, respectively; Cox, the B.S. in civil engineering from University of Tennessee; DePierri, the B.A. degree in chemistry from Vanderbilt University and the Ph.D. from University of Illinois; and Thomas, the B.S. degree in mechanical engineering from Louisiana Polytechnic Institute and the M.S. from Northwestern University.

Irving Pollock has been named regional manager, Houston, of Texaco's Technical Services division, the company's field organization which provides engineering and research services to Southwest industry.

Before taking up his new assignment in Houston, Pollock was technologist in Texaco's Chicago Technical Services headquarters.

Pollock joined Texaco in 1939. He obtained a B.S. degree in chemistry at Colorado Agricultural and Mechanical College.

He commenced work at the company's Sunburst, Mont., refinery and in 1941 was transferred to the Texaco Research Center, Beacon, N. Y. From 1949 to 1951 he was staff assistant to the director of Technical Services at Beacon.

In 1951 Pollock was assigned to the staff of the manager of Technical Service division in New York and held that position until 1955 when he was appointed to the Chicago regional office.

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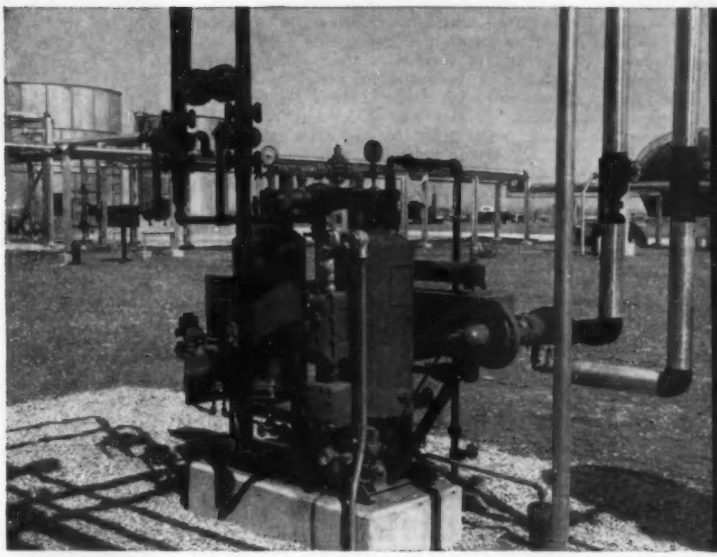
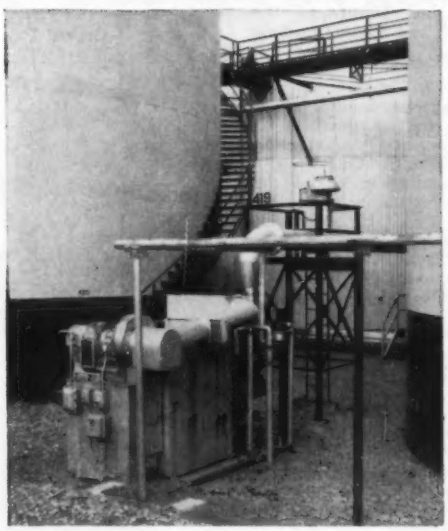


Type BWG Lectrodryer DRYing instrument air at a refinery

Lectrodryer



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What Suppliers Are Doing . . .

Henriksen

Arnold H. Henriksen has been appointed to the newly-created position of manager of the Mountainside, N. J. plant of Beckman Instruments' Helipot division. Henriksen will direct administrative, sales, engineering and production functions of the New Jersey operation. He has been a member of the New Jersey staff since 1953, has served as production manager and chief production engineer. Prior to joining Beckman-Helipot, he held production management positions with Air Associates, Teterboro, N. J.; Economics Lab, Inc., Lyndhurst, N. J.; and Detroit Harvester Co., Zanesville, Ohio.

Strobel

John R. Strobel has been appointed sales engineer at Garlock Packing Co.'s Denver branch. Strobel will serve a territory consisting mainly of Nebraska and Arizona. He is a graduate of the University of Colorado, holding a B.S. degree in business finance. He was previously associated with the Black and Decker Manufacturing Co., Denver, as a sales representative.

Mitchell

John A. Mitchell, Jr., has been made assistant to the president of Milton Roy Co. He replaces G. J. Wilson who was recently appointed general manager of Milton Roy's new plant in St. Petersburg, Fla.

For the past two years, Mitchell has been order service manager and formerly was an application engineer.

Graduating with a B.S. degree in mechanical engineering from Cornell University in 1948, Mitchell's former industrial experience was as a sales engineer with Worthington Corp. He is a member of the Instrument Society of America and the Cornell Society of Engineers.

Fino

Alex F. Fino has been appointed chief engineer of the Hammond Iron Works. A native of Warren, Penn., Fino is a graduate of the University of Pittsburgh with a B.S. degree in mechanical engineering. He has been associated with the Hammond Iron Works since 1940.

Fino has had the principal responsibility for the design and development of various Hammond patented products. In addition to commitees of the American Petroleum Institute on evaporation loss and tank standardization, he is active with technical groups of the American Welding Society and American Society of Mechanical Engineers. A technical paper by Fino on Field Erection Methods was recently published in the Welding Journal.

He is a member of the Sigma Tau and Pi Tau Sigma honorary Engineering societies and was listed in the 1956 edition of "Who's Who in the East."

Doak

Barney R. Doak has been named manager of Canadian sales and service for W-K-M, Division of ACF Industries, Inc. Doak, who was formerly with Parkersburg Rig and Reel Co. as a sales engineer, will cover the expanding oil and gas industry in Canada. He will have his headquarters in Calgary. W-K-M is a manufacturer of valves and fittings for the oil and gas industry.

Gerald T. Hughart has been named general manager of the Klemp Metal Grating Corp. Hughart, a native of Colorado, joins Klemp from Stearns-Rogers Manufacturing Co., Denver, where he held such positions as manager of manufacturing and sales engineer in charge of process equipment sales.

Hughart was associated with General Motors in various divisions for seven years, and was with the Research Development section of the Army Ground Forces for two years prior to his association with the Stearns-Rogers Co.

Hughart

James M. Barrens has been appointed unions sales representative for Clayton Mark & Co. in the eastern coastal states. Barrens will represent Claytown Mark, Evanston, Ill., manufacturer of forged steel unions and forged steel fittings in the industrial areas on the east coast and in Montreal.

For the past seven years Barrens has been a buyer of pipe valves and fittings for The Lummus Co., New York, design and construction engineers for the oil and chemical industries.

Barrens

James W. Caswell has been named Southeastern representative for the Socket Screw division of The Bristol Co., Waterbury, Conn. Caswell graduated from Georgia Tech with a degree in Industrial Management in 1950. He has been associated with Gordon Foods of Atlanta since that time.

Caswell will be headquartered in Atlanta, Georgia, at the Bristol branch office there. He will contact industrial distributors handling Bristol's line of socket screw products in the seven states of Alabama, Georgia, Florida, Mississippi, Tennessee, and the North and South Carolinas.

Caswell

Ray St. Onge has been appointed product manager for all instruments of the Process Instruments division of Beckman Instruments, Inc. St. Onge was formerly on the Beckman field engineering staff, having the responsibility of the New York and Detroit areas. He received a B.S. degree in chemical engineering from the University of Detroit, and has been active in the Instruments Society of America, AIChE, TAPPI and Engineering Society of Detroit.

St. Onge

Russell L. Sylvester, chief engineer of Rockwell Manufacturing Co.'s Central Valve Research and Development department, has been promoted to engineering executive assistant of Republic Flow Meters Co. of Chicago, newly acquired Rockwell subsidiary.

Sylvester will be primarily responsible for coordinating engineering and sales activities of the two companies. A registered professional engineer, Sylvester spent a number of years as director of project engineering, Kinney Manufacturing Co. (division of N. Y. Air Brake, manufacturers

Sylvester

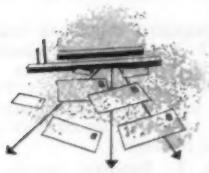
CREDO FOR THE NEW *Patterson*

of interest to every customer

WE BELIEVE IN CLOSE CUSTOMER RELATIONS

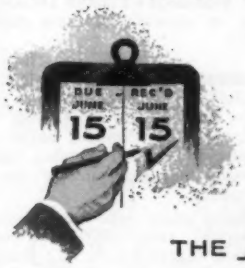
We believe that the closer our understanding of your operations and problems, the greater is our capacity to serve your interests. Accordingly we are organized throughout sales and engineering for the maximum application of study to your needs, with continual close contact maintained for the duration of every project. (We are ready when you are.)

WE BELIEVE IN PROMPT INQUIRY HANDLING



Because inquiries can smother in piles of paper, our inquiry processing is fast and thorough. A complete Customer Service Department has full responsibility for preparing specifications to your requirements, formal quotations, order entering, and the processing of sales correspondence and relative communications. (May we have your inquiry?)

WE BELIEVE IN KEEPING DELIVERY PROMISES



The whole Patterson organization becomes part of the promise when a delivery date is made. Fallibility is human, but we set our sights squarely on the target's bull's-eye from the day the promise is made—and our score is close to perfection today. (When do you need that new equipment?)

THE *Patterson* FOUNDRY AND MACHINE COMPANY

ADVANCED
PROCESS EQUIPMENT
OF ENDURING SATISFACTION

A Subsidiary of Ferro Corporation

East Liverpool, Ohio, U.S.A.

THE *Patterson* FOUNDRY AND MACHINE CO. (CANADA) LTD
Toronto, P.O., Canada

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

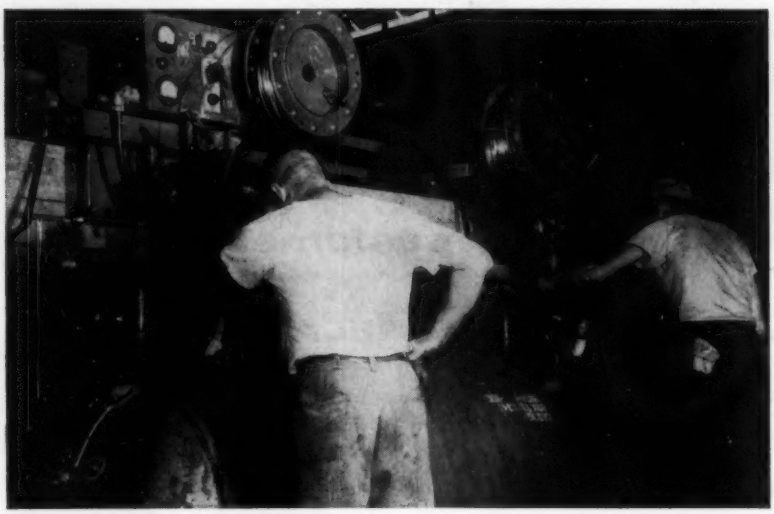
of pumps and valves). He was also manager of engineering, National Research Corp., builders of high vacuum equipment.

PLIBRICO CO. has appointed **Harold G. Lines** as Chicago sales engineer. Lines joined Plibrico from Magnetic Metals Co. where he was Midwest district sales manager. A member of the American Society for Metals and the American Welding Society, Lines will service refineries, steel mills and cement plants in the Hammond and Chicago areas.

CONSOLIDATED ELECTRODYNAMICS CORP. has established a new division to specialize in the engineering, design, and manufacture of a standard instrumentation line of magnetic-tape recording and reproducing equipment. It will be called the DataTape division.

Philias H. Girouard, formerly assistant director of engineering, was appointed director of the new division. Prior to joining CEC last year, Girouard was for 13 years chief engineer of the U. S. Navy Bureau of Ordnance.

Other appointments in the new DataTape division include **Herbert Karsh,** chief engineer; **Burt W. Cobb,** manager of manufacturing; and **Rear Admiral Jackson S. Champlin,** USN (Ret.), administrative manager. Quality control is under direction of **A. B. Cook.**



LINCOLNWELD'S
PRECISION CONTROLS INSURE

uniform quality on every weld

The operator is in complete control of every job with Lincolnweld Automatic Submerged Arc Welders. And once procedures are established, production work is uniform and consistent. Infinitely variable speed and current controls guarantee the highest quality weld on every job . . . and at lowest cost.

FABRICATORS! *Bulletin SB-1355 contains data and specs on all Lincolnweld Submerged Arc Welders. Write for it!*

THE LINCOLN ELECTRIC COMPANY
Dept. 2210, Cleveland 17, Ohio
The World's Largest Manufacturer of Arc Welding Equipment

When Lincolnweld Automatic Welders **H**ave more versatile controls **Y**et cost less . . . **WHY** use anything but Lincolnweld?

UNIVERSAL OIL PRODUCTS CO. has announced the development and commercial availability of a new sweetening inhibitor which employs a selective catalyst to promote more rapid oxidation of sulfur compounds in gasoline.

The new product—an important addition to Universal's list of gasoline additives—is UOP No. 5-S. The formulation, the company said, has been proved in laboratory tests and commercial usage to be even better than previous inhibitors for applications where inhibitor sweetening is the controlling factor in the choice of inhibitor used.

Retaining the potency and water-insolubility characteristics of UOP No. 5 Inhibitor, the new additive accomplishes sweetening in one-fourth to three-fourths the time ordinarily required with UOP No. 5 depending upon the mercaptan content and other conditions. The new inhibitor now makes it possible to readily sweeten many gasolines which heretofore had been considered impractical for inhibitor sweetening.

TRACERLAB INC. board of directors has elected **Homer S. Myers** to fill the newly created post of vice-president for marketing. Myers was one of the founders of the firm and has been general manager of its Industrial division. The new marketing division will implement the firm's marketing activities with responsibility for the sale of the company's nuclear and industrial products and services and for marketing services to the X-ray sales effort.

DE LAVAL STEAM TURBINE CO. has announced five organizational changes to expand the supervisory team of its manufacturing division.

Paul S. Nurko is new general superintendent of all production shops and **Leonard Schwarz** is superintendent of the Main Shop. **Kenneth Lippincott** has been named superintendent of the standard products shops, **Milton Hammond** superintendent of the turbocharger shops and **Joseph Basso** a supervisor of manufacturing research, dealing with special tooling and equipment problems.

MONSANTO CHEMICAL CO. has promoted **C. F. Brunson** to the position of assistant to the director of sales, resin products, Seattle, for Monsanto's Plastics Division. He had been sales manager of the Western adhesives department and Seattle district manager.

A. L. Bonutto, Seattle, has been promoted to sales manager, Western adhesives sales and Seattle district manager for Monsanto's Plastics Division after serving as assistant in those capacities since 1954.

HOOKER ELECTROCHEMICAL CO., Niagara Falls, N. Y., has opened a new district sales office at 6 Penn Center Plaza, Philadelphia 3, Pa. **Neil M. Barber** is manager-Philadelphia district sales, while **John J. Wojnar** has been named the new office manager.

The office will be headquarters for chemical sales representatives **Julian J. Boyce,** Charlotte, N. C.; **Joseph J. Lenahan,** Pittsburgh, Pa.; and **Charles H. Foster, Jr.,** who will move shortly from New York to the Philadelphia area. The office will also be headquarters for Durez Plastics division representatives **Robert W. Bainbridge, Michael G. Dubenitz** and **Alexander L. Blackwell.**

Barber, a native of Vermont, joined

Smith FORGED STEEL **Valves**

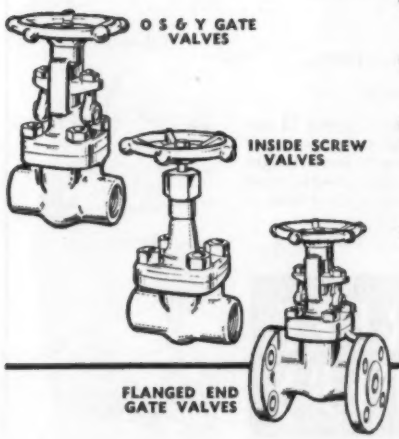
Because you asked for it...

SMITH "FIGURE 100" NEEDLE GLOBE VALVE

These are the Features and Qualities engineers asked for in the new SMITH forged steel, union bonnet NEEDLE GLOBE VALVE

- **Forged Steel** body and union nut guarantee maximum strength and highest factor of safety.
- **Union Bonnet Design.** The bonnet of a "Smith Figure 100" cannot come loose in service due to vibration.
- **Rolled Stem Threads** (30% stronger than cut threads) insure smooth, positive, non-galling operation.
- **Diamond Hard** chrome plated stainless steel stems, used in Figures 100A and B valves, minimize galling.
- **Cadmium Plated** bonnet and packing nut resist atmospheric corrosion — stuffing box is always tight.
- **Positive Stem and Bonnet Top Seat** at full open position — a highly important safety feature.
- **Packing**—Special plastic compound containing asbestos fiber, synthetic rubber and graphite combined with stainless steel retaining rings insures excellent results at high temperatures and pressures. Teflon packing supplied on special orders.
- **Cross-Bar Type Handle,** malleable iron, for easy opening and closing.

Guaranteed to give you longer, trouble-free life in service.



NEW ENGLAND VALVE *Corporation*

P. O. BOX 1047 • WORCESTER, MASSACHUSETTS

West Coast Distributors: BETHLEHEM SUPPLY CO., LOS ANGELES, CALIFORNIA

For more data on advertised products, use Readers' Service Cards, last page.

KAMLOK
QUICK COUPLERS

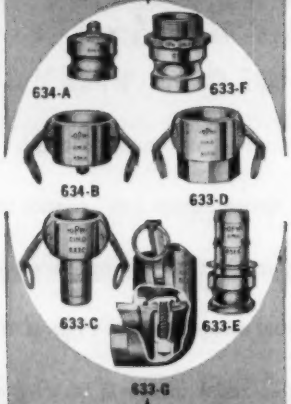
633-A

633-B

OPW CORPORATION
OPW
CINCINNATI 25, OHIO

SLIPS ON
CAM TIGHTENS
HOLDS TIGHT
NEVER FAILS

The Fastest, Safest, Surest Coupling Known



KAMLOK

BRONZE • ALUMINUM • MONEL
STAINLESS STEEL • SEMI-STEEL

ALL STYLES OF ADAPTORS FIT IN ALL STYLES OF COUPLERS OF THE SAME SIZE.

Perfectly tight, no leak connection in seconds. Kamloks couple and uncouple instantly regardless of "hook-up".

Write for Free Bulletin F-10

JORDAN CORPORATION
Industrial Sales Division of OPW Corp.
6013 Wiehe Road • Cincinnati 13, Ohio

Suppliers . . .

Hooker in 1942 upon graduation from Dartmouth College. He transferred to sales in 1945, and has represented Hooker in the Philadelphia area since 1948, being named district sales manager a year ago.

Wojnar served four years in the Navy, where he became an aviator, and in 1954 graduated from Wilkes College with a B.S. degree. Formerly of Ashley, Pa., he joined Hooker in 1954 as an analytical chemist in the research and development department, transferred to the sales coordination group in January, 1956, and has recently moved from Niagara Falls to Elkins Park.

INTERNATIONAL NICKEL CO., has added **John B. Adamec** to the staff of the company's Research Laboratory at Bayonne, N. J., as a research metallurgist. He will work in the field of platinum metals, including the preparation of alloys of the platinum metals through powder metallurgy.

Adamec is a graduate of New York University, from which he holds an M.S. degree in metallurgy and a B.S. degree in chemical engineering.

From 1950 to 1957, he served as research metallurgist and chief metallurgical engineer with the Sintercast Corp. of America. Adamec held the position of research metallurgist with the American Electro Metal Corp. from 1947 to 1949, and in 1946-47 he was a research engi-

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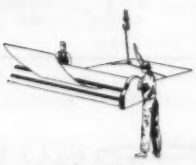
LINCOLN ELECTRIC CO., LTD., has completed and moved into a new and larger factory in England. The new plant, located in Welwyn Garden City, Herts., covers 190,000 square feet and is an interesting example of modern industrial architecture. Utilizing welded tubular steel frame-work, the building incorporates a saw-tooth-type roof permitting 180 north-light bays, each 50 feet long, representing an acre of glass area. The new and modern plant is the largest of its type in England. The building will house additional production facilities as well as Production Control and Analytical Development Laboratories and provide additional area for Welding School facilities.

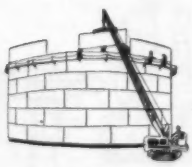
Specialists
IN TANK AND VESSEL—



Fabrication

Design, Fabrication, Erection, Testing and Repairs

Tanks and vessels—from the first preliminary design to the finished job, completely tested and ready for service—are our exclusive interest. We have no other departments. Every thought is given to producing the very best tank or vessel possible. Next time, let us figure your requirements—whether it's one tank or a hundred-plus tank farm installation.



Erection

ELLERBEE BROTHERS

P. O. BOX 857 PORT ARTHUR, TEXAS

X-Ray Testing

Your Guide to the Best in Aluminum Value

FREE

THIS 12" SAMPLE OF ALCOA ALUMINUM CONDUIT

ALCOA RIGID CONDUIT IS EASIER AND MORE ECONOMICAL TO INSTALL,

SAY CONTRACTORS

The contractors who installed the electrical system in Alcoa's 30-story office building and in every new Alcoa plant erected in the past ten years agree on this point.

Aluminum rigid conduit installs easier, faster and at lower cost than any other!

Alcoa® Aluminum Electrical Rigid Conduit is easier to cut . . . easier to bend . . . easier to thread.

It weighs two-thirds less than steel . . . which makes it easier to handle, less costly to ship, easier to stockpile at job site.

From the long-range viewpoint, there are other savings:

No staining or corrosion . . . and no painting

Up to 20% less voltage drop

Greater safety in hazardous locations . . . because aluminum is nonsparking

Alcoa Rigid Conduit has Underwriters' Laboratories approval. Suitable fittings are available. And adequate stocks are maintained throughout the country by Alcoa distributors.

Why not get all the facts on this timesaving, more profitable conduit? The coupon below will bring you complete literature and a generous sample.

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Aluminum Company of America
2325-H Alcoa Building
Pittsburgh 19, Pa.

Please send literature on *Alcoa Aluminum Electrical Rigid Conduit* and a one-foot sample.

Name_____

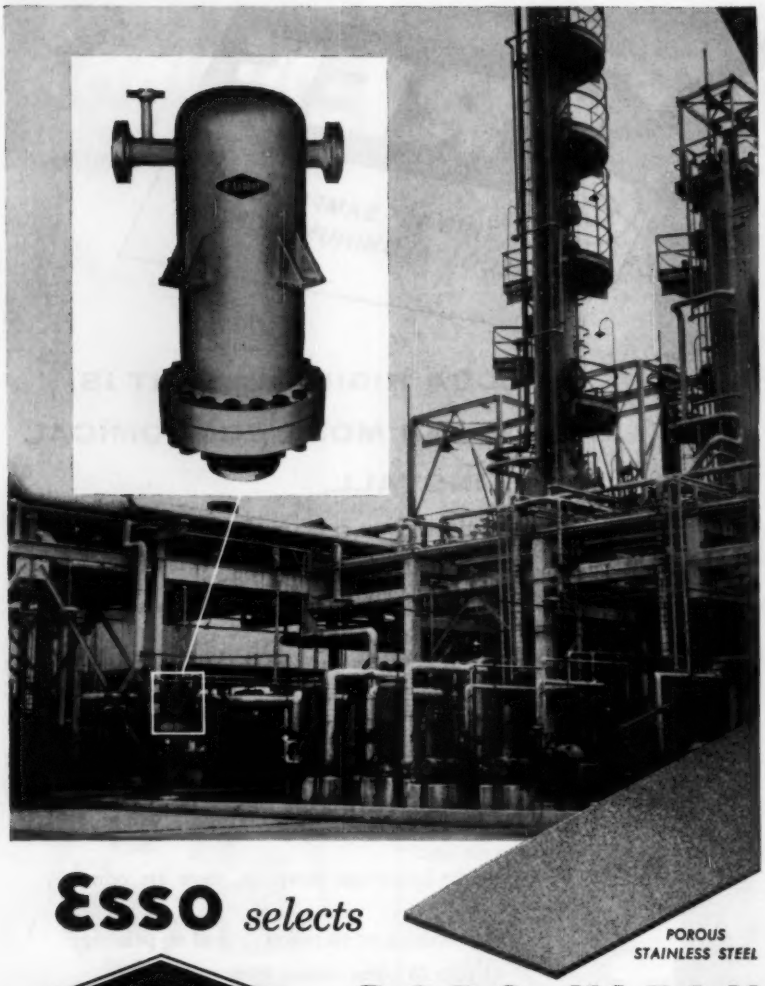
Title_____

Company_____

Address_____

City and State_____

For more data on advertised products, use Readers' Service Cards, last page.



Esso *selects*

POROUS STAINLESS STEEL

CUNO

PORO-KLEAN
FILTER
for HYDROFINER

To remove catalyst fines from the Hydrofiner outlet stream – and thus prevent catalyst poisoning in the "reformer" – Esso selected a Cuno Poro-Klean Filter for its Baltimore, Maryland refinery. The fluid, heavy virgin naphtha of approximately 52.7 API, reaches the filter at 350°F. The Cuno Filter is a completely standard unit. Housing includes integral arrangements for in-place cleaning by backflushing and is built to meet A.S.M.E. Code requirements. For easy inspection, individual cartridges of sintered stainless steel are employed. The porous metal filter material manufactured by Cuno features a carefully controlled porosity that insures uniform fine filtration with complete removal of all catalyst particles.

Cuno Filters are now in service throughout the Petroleum Industry handling–

PRODUCT STREAMS **COMPRESSED AIR** **PROCESS STREAMS**
CHEMICALS **STEAM** **SERVICE FLUIDS** **ADDITIVES**

WHATEVER YOUR FILTRATION PROBLEM . . . you can look to Cuno for the best possible unit to meet *your* specific needs. Remember ONLY CUNO offers you a truly complete line that includes all 5 types of filter media –

EDGE-TYPE • WIRE-WOUND • SCREEN • FIBER CARTRIDGE • POROUS METAL

CUNO **CUNO ENGINEERING CORPORATION**

3408 SOUTH VINE STREET, MERIDEN, CONN.

Designers and Manufacturers of Filters for Over Thirty Years

Suppliers . . .

neer with the New York University Research division.

Several patents in the field of cermets and powder metallurgy have been issued with Adamec as co-inventor.

Rufleth

Neale

THE BRISTOL CO., Waterbury, Conn., has named **Walter E. Rufleth** manager of Telemetering Systems Applications, and **Kenneth R. Neale** manager of Electronic Products Applications.

Rufleth has had wide experience in the application of the company's Metameter Telemetering systems for remote measurement and control, and in the public utility field in general. He and his group will be responsible for the application of telemetering systems for water, gas, oil, and power, and for special instrument applications in utility areas.

Neale and his group will be responsible for the application of recording and controlling electronic potentiometers and bridge instruments, pH and conductivity equipment, electronic pressure and temperature controllers, and millivoltmeters.

Both men will continue to operate out of the Application Engineering department.

THE GIRDLER CO., Louisville, Ky., has won top honors for the design and typographical excellence of a unit of literature in the fourth annual exhibit of advertising and editorial art sponsored by the Art Directors' Club of Milwaukee.

The prize winning literature was a brochure that describes Girdler's catalyst facilities. It was produced under the direction of **Everett Andes,** advertising manager of The Girdler Co. and Tube Turns, divisions of National Cylinder Gas Co., Chicago.

UNITED STATES STEEL CORP. has appointed **Thomas L. Campbell** assistant manager tubular sales at Los Angeles for U. S. Steel's Oil Well Supply division.

Campbell was employed in 1937 at Wilmington, Calif. He left the employ of "Oilwell" in 1948, returning in 1952 as assistant district manager at Long Beach, Calif. In 1955 he was appointed assistant manager tubular at Los Angeles and in 1956 assistant manager production equipment sales, Long Beach. During World War II he served in the United States Navy.

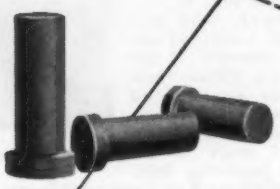
ROBERTSHAW-FULTON CONTROLS CO. has announced the election of **Thomas T. Arden** as president and of **John A. Robertshaw,** former president, as chairman of the board.

Robertshaw immediately announced the formation of a three-man executive com-

AIRCRAFT QUALITY

ALLOY CASTINGS

...for the special requirements of your industry



METALS PROCESSING DIVISION FOUNDRY handles wide range of sizes, closely controls dimensions

Precision testing methods provide close control of casting quality

Curtiss-Wright's Metals Processing Division today offers your industry precision castings of critical parts in a wide variety of sizes, and with closely controlled dimensions. For example, in the large casting shown, tolerance is ±.030 over 36″ diameter. From its modern, completely equipped foundry in Buffalo, the Division supplies heat, corrosion and abrasion resistant castings from a full range of special-property alloys, including ductile iron...by sand, centrifugal, ceramic or shell processes.

Precision alloying techniques, modern melting controls with spectrometer testing, X-ray control by experienced radiographers — all add up to castings with superior physical and mechanical properties . . . mean better and more dependable products for the critical needs of industry. Qualified design engineering assistance is a part of the comprehensive Metals Processing Division service. Write for details.

70 Grider Street

METALS PROCESSING DIVISION
CURTISS-WRIGHT CORPORATION · BUFFALO, N. Y.

Metals Processing Division Branch Offices: New York • Houston • Los Angeles

For more data on advertised products, use Readers' Service Cards, last page.

This tube support is 21'6" long; 6'7" wide and weighs 8900 pounds. It looks like a single casting. Actually it is made up of three sections welded together in zig-zag strips across the face. It's a Duraloy HH casting destined for an oil refinery cracking still.

Welding is assuming greater and greater importance in the production of high alloy castings. Often it is the only way to produce large tonnage or unusually shaped pieces. During our many years of experience in producing both high alloy static and centrifugal castings, we have developed sound welding techniques for such castings. Carbon steel welding techniques won't serve. It takes special know-how for chrome-iron and chrome-nickel.

You can rest assured that if the chrome-iron or chrome-nickel castings you order from us require any welding, it will be done skillfully.

DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 74—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

Suppliers . . .

mittee headed by **Richard S. Reynolds, Jr.**, former chairman of the board. The committee includes Robertshaw and Arden.

Arden, executive vice president of the firm since 1947, will assume his new duties immediately. He was in charge of the company's Western operations, including two manufacturing divisions and a research center, now nearing completion. Active in industry affairs, he was president of Gas Appliance Manufacturers Association in 1954-1955, and is current president of Pacific Coast Gas Association.

Robertshaw has been president of the company since 1947. Prior to that time, he was president of Robertshaw Thermostat Co., Grayson Heat Controls, Ltd., and American Thermometer Co. A veteran controls executive, he has spent most of his business career selling and manufacturing automatic devices.

ARMSTRONG CORK CO. has announced that **John J. Roper**, assistant district manager of the Boston Office of the company's Insulation division, has been appointed district manager, succeeding **T. R. Nunan**, who retired effective June 1.

John J. Roper

Roper, who was named assistant district manager of the Boston Office some months ago, joined Armstrong with an established background of 24 years in the heat insulation field. Active in the New England Asbestos Contractors Association, he is a past president of the organization and is currently a member of its executive committee.

Roper graduated from Suffolk University in 1941, with a Bachelor of Laws degree.

Prior to establishing and operating the T. R. Nunan Company, he served as Vice President and General Manager of the Cork Import Corporation, an Armstrong subsidiary, and as Vice President and General Manager of Armstrong's Insulation division. Earlier, he had been district manager of the Cleveland, Pittsburgh and New York Offices and had served at the Atlantic Office in a sales capacity and at Pittsburgh in sales and as general superintendent of construction.

ENJAY CO., INC., has announced the opening of a new sales office at 16301 West Seven Mile Road, Detroit, and another at 1410 Canal Street, New Orleans.

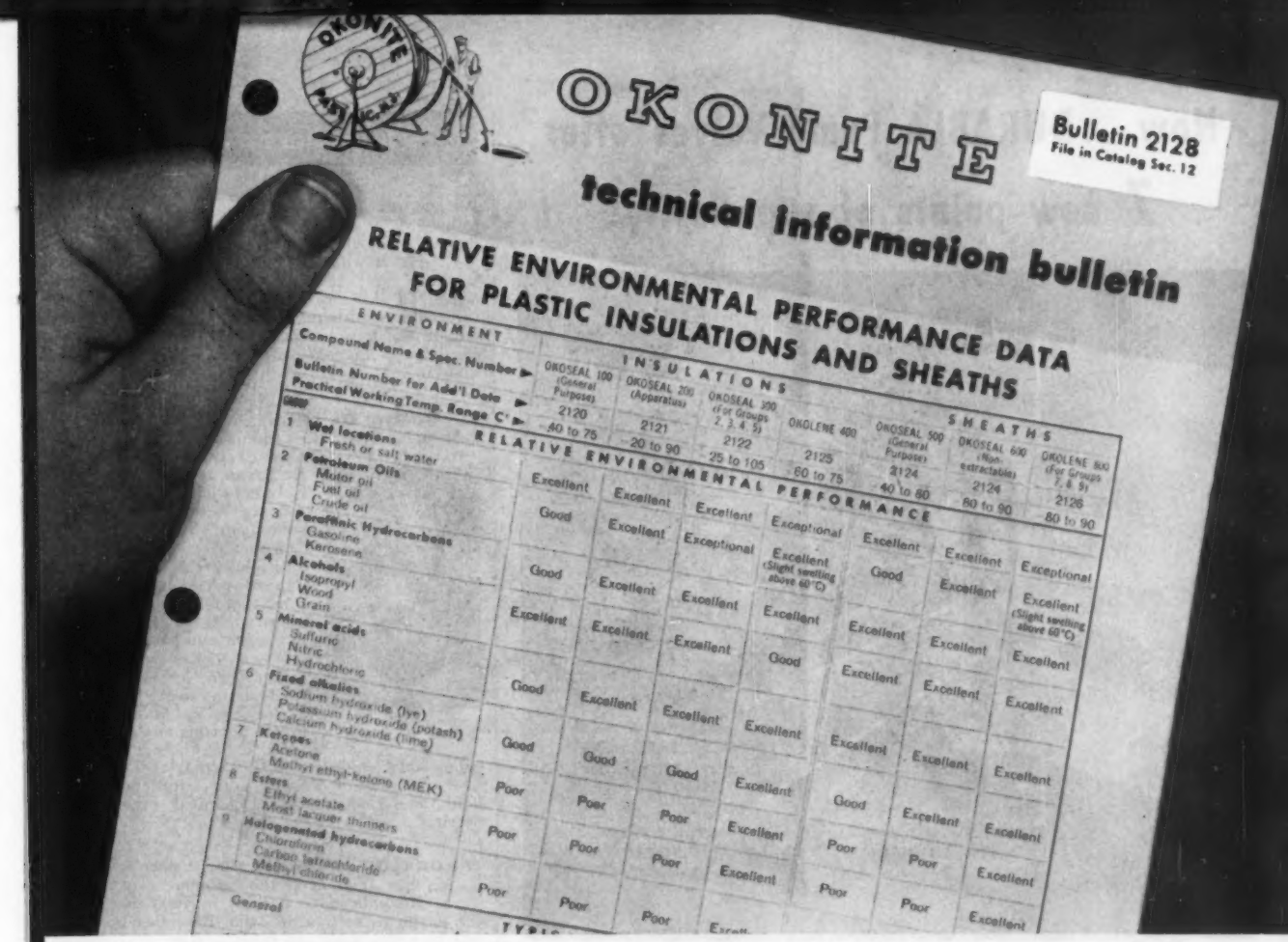
At the same time the company announced a change of address for its

Free to
PETROLEUM REFINER Subscribers

Write for free booklet on preparation of articles for PETROLEUM REFINER, the technical press generally, as well as papers for technical meetings.

Use Readers' Service green cards in the back of this issue. Write on the card "Free Author's Booklet," fill in name, address and mail. No charge, no obligation.

For more data on advertised products, use Readers' Service Cards, last page.



How to pick the correct plastic cable for your specific need

Bulletins prepared by Okonite's Engineering Department will help you select the optimum plastic-insulated electrical cables for various applications in your plant. These bulletins, compiled especially for the refining, natural gas and petrochemical fields, describe the several available Okoseal (polyvinyl chloride) and Okolene (polyethylene) insulation and sheath compounds. They provide, in detail, the dimensions, applications and the resistance of each to such environmental conditions as salt water, petroleum oils, paraffinic hydrocarbons, alcohols, mineral acids, fixed alkalies, ketones, esters and halogenated hydrocarbons.

Using these bulletins, you can choose the most effective insulation and sheath material for each environment. Okonite can provide you with longer-lived, more reliable circuits for power, control, machine tool, lighting circuit, motor lead, switchboard, communication and cathodic protection. Check and send in this coupon for complete information on Okonite plastic wires and cables.

THE OKONITE COMPANY, Passaic, N. J.
Kindly send me the free bulletins checked below.

- ☐ **BULLETIN 2120**—Insulated Power and Control Cable—600 Volts (Okoseal 100)
- ☐ **BULLETIN 2121**—Machine Tool and Switchboard Wire—600 Volts (Okoseal 200)
- ☐ **BULLETIN 2122**—High Ambient Petroleum and Chemical Resistant Wire—600 Volts (Okoseal 300)
- ☐ **BULLETIN 2123**—Oil and Gas Resistant Wire—600 Volts (Okoseal-Nylon, Type OGR)
- ☐ **BULLETIN 2124**—Multi-Conductor Control Cable—600 Volts (Okoseal 100)
- ☐ **BULLETIN 2125**—Insulated Power and Control Cable—0-5000 Volts (Okolene 400)
- ☐ **BULLETIN 2126**—Multi-Conductor Control Cable—600 and 1000 Volts (Okolene 400)
- ☐ **BULLETIN 2127**—Cathodic Protection Cable (Okolene 400)
- ☐ **BULLETIN 2128**—Relative Environmental Performance Data for Plastic Insulations and Sheaths

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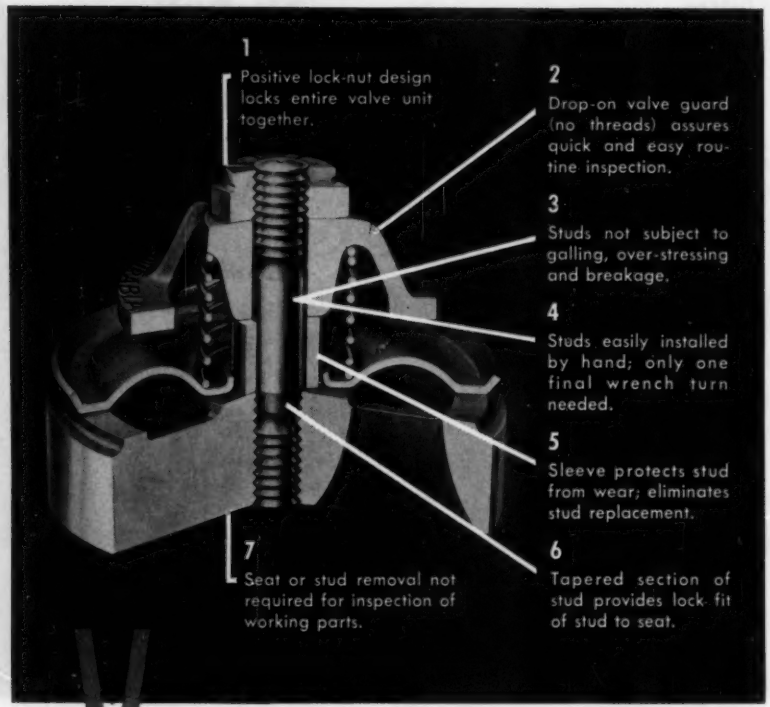
where there's electrical power . . . there's **OKONITE CABLE**

Now...DURABLA Pump Valves offer 7 new points of superiority!


1
Positive lock-nut design locks entire valve unit together.
2
Drop-on valve guard (no threads) assures quick and easy routine inspection.
3
Studs not subject to galling, over-stressing and breakage.
4
Studs easily installed by hand; only one final wrench turn needed.
5
Sleeve protects stud from wear; eliminates stud replacement.
6
Tapered section of stud provides lock fit of stud to seat.
7
Seat or stud removal not required for inspection of working parts.

New V-design assures even greater dependability

You want *maximum valve dependability* for your reciprocating pumps . . . and DURABLA gives you just that in the new V-7 unit.

Incorporating seven points of superiority, the new valve features a tapered or V-shaped stud which screws down tight to the seat. This exclusive design anchors the stud, eliminating any possibility of galling, over-stressing or breakage. What's more, the new self-locking nut and drop-on guard assure quick and easy inspection of working parts—without stud or seat removal.

Remember: In the DURABLA Valve, only "point contact" is made by the valve member on the stud sleeve, so it can't bind or hang-up. The open-type guard assures free flow of liquid, prevents clogging.

These stainless-steel valves operate freely under temperature extremes, with corrosives, and in any position. Made in 15 sizes to fit any reciprocating pump, old or new.

Send for *NEW* 8-page booklet PR-87.

Keep your pumps fit with the valves that fit all pumps.

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DM-26

DURABLA MANUFACTURING COMPANY

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Suppliers . . .

Western division headquarters in Chicago from 221 North LaSalle Street to Prudential Plaza, 130 East Randolph Drive.

G. H. Lowden is engineering representative and manager of the Detroit office. In this capacity he is responsible for contacts with the automotive industry on all Enjay products. **W. F. Wadt** will continue as manager of Enjay's Western division.

BAILEY METER CO. has named **K. T. Bridgman** manager of the company's Schnectady district office. Bridgman succeeds **J. F. Luhrs** who has been assigned to the Cleveland main office.

K. T. Bridgman

Bailey Meter, whose headquarters is in Cleveland, manufactures instruments and automatic controls for the power and process industries.

Bridgman, formerly resident engineer in Springfield, Mass., joined the company in 1926. A registered professional engineer in Massachusetts, he is a graduate of Purdue University and holds a B.S. degree in mechanical engineering.

THE GARLOCK PACKING CO., Palmyra, N. Y., has announced the assignment of **T. E. Broomhead** to a sales territory in the northeast section of Ohio. Broomhead was formerly with the Boston office.

THE ENJAY CO., INC., New York, has announced the appointment of two new personnel in the Market Development division.

Dr. L. T. Eby is the newly appointed senior market development engineer responsible for industry information. He was formerly a research chemist with Enjay's research affiliate.

Dr. Eby received his Ph.D. degree from Notre Dame in 1941. He also did his undergraduate work there. He is chairman of the membership committee of the American Institute of Chemists, as well as chairman-elect of the New Jersey Chapter.

Frank C. LaMotta has also joined the market development division at Enjay. He was formerly with E. I. duPont de Nemours & Co., Inc., and is a graduate of Seton Hall University.

ALLIED CHEMICAL & DYE CORP. has anpointed **Dr. Raymond L. Copson** assistant to the director of development of the Solvay Process division. Dr. Copson has been in charge of Research and Develop-

Did You Read "Changing Times" on Page 239?

—Photo courtesy Standard Oil Company (N.J.)

How preheat makes a "30-hour day"

When you add a Ljungstrom® Air Preheater, your on-stream stills can give 30 hours of normal production in every 24 hours. That's more than an extra week of production every month!

The reason is that Ljungstroms recover valuable BTUs that are normally dissipated up the stack. By putting this heat back to work, higher flame temperatures are generated, heat transfer rates increased. You can save one barrel of fuel in every five, stay on-stream months longer because slag is virtually eliminated.

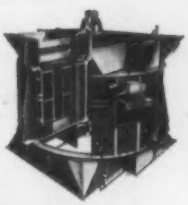
LJUNGSTROMS ARE WRITTEN OFF FAST

A Ljungstrom can pay out in nine months or less! The many other advantages show why: use of fuels you formerly threw away . . . more economical furnace design with no need for convection surfaces . . . minimum slag . . . shorter turn-around time . . . higher quality product (averaging 2 octane numbers higher than previously).

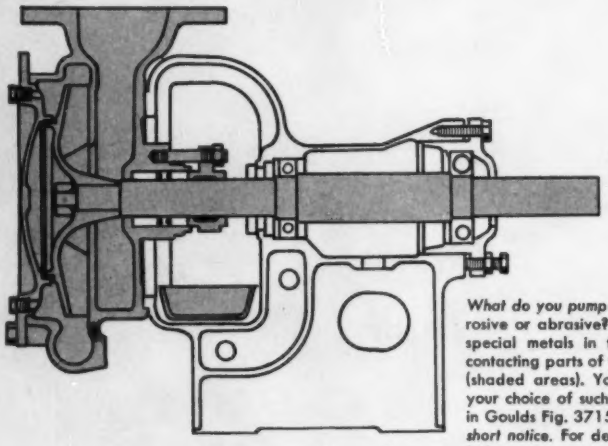
Detailed information is available. Learn about Ljungstrom's compactness, easy inspection, simplified cleaning, minimum maintenance, and the amazing economy and reliability story. Just call or write the Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.



The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.



What do you pump that's corrosive or abrasive? You need special metals in the liquid-contacting parts of your pump (shaded areas). You can get your choice of such materials, in Goulds Fig. 3715 pump, on short notice. For details, read below.

Solve your corrosive-abrasive pumping problem by choosing one of these 6 quick answers

You can meet a wide range of corrosive and pumping requirements with this *one* Goulds pump.

The reason? The pump comes in *six* different corrosion- and abrasion-resistant constructions.

And you can get Goulds Fig. 3715 pumps in every one of these constructions on short notice—*from factory stock.*

Here are the six constructions:

Type 316 Stainless
Gould-A-Loy 20
All Iron
Nickel Aluminum Bronze
Bronze Fitted
Iron with Stainless Trim

But that's not all. You can pump liquids as hot as 350° F. by cooling the support head and quenching the gland through built-in fittings.

You can locate the pump almost anywhere because grease-lubricated bearings are completely sealed to keep out dirt and moisture.

You can adjust the distance between impeller and casing without removing the end casing.

You can make routine service checks or replace the impeller without disturbing piping connections.

You can keep spare parts inventory low because of the high degree of interchangeability of parts between sizes.

You can get Goulds Fig. 3715 pumps in any of nine sizes with capacities to 720 GPM and heads to 200 feet. To get the full story, send for Bulletin 725.4.

GOULDS

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CORROSION-RESISTANT PUMPS

GOULDS PUMPS, INC.
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CHICAGO, 53 West Jackson Blvd.
HOUSTON, 2314 Main St.
NEW YORK CITY, Room 1503, 11 Park Place
PHILADELPHIA, 2099 North 63rd St.
PITTSBURGH, Room 512 Bessemer Bldg., 104-6th St.
TULSA, 543 East Apache St., P. O. Box 6157

West Coast Representative: GOULDS PUMPS Western, Inc., 1919 N.W. Thurman St., Portland 9, Oregon
In Canada: The A. R. Williams Machinery Co., Ltd.... in all principal cities

Suppliers . . .

ment for Mutual Chemical at the latter's Baltimore Laboratory. Mutual Chemical has been affiliated with Solvay Process since January 1, 1957.

A native of Massachusetts, Dr. Copson holds B.S. and M.S. degrees from Worcester Polytechnic Institute and obtained his Ph.D. degree in chemical engineering at Yale University. He has been with Mutual Chemical since July, 1949.

Dr. Copson will make his headquarters at Solvay's research and engineering center in Syracuse.

MILTON ROY CO. has announced the appointment of **G. J. Wilson** as general manager of the company's new Florida plant. Wilson was formerly assistant to Milton Roy's president, Robert T. Sheen.

Wilson

Also **George W. Schneider** will be manager of research and development of the Analytical Instrument division while **Milton R. Sheen** will become manager of manufacturing for the new plant.

A registered professional engineer, Wilson is a graduate mechanical engineer having received his degree from Stevens Institute of Technology in 1946. He is also a graduate of the management course of the American Management Association. His engineering experience includes chemical feeding systems for Milton Roy and power rectifier substations for General Electric Co.

Wilson is a member of the Instrument Society of American and the Aircraft Owners and Pilots Association. Formerly from Hatboro, Pa., he plans to move to St. Petersburg, Fla. this summer.

A. O. SMITH CORP.'s Electric Motor division has added two new manufacturer's agents. **J. Carl Turner,** Miami, will cover Florida, while New England will be handled by **George Curley, Jr.,** Quincy, Mass.

JEFFERSON CHEMICAL CO. has formed a new division to market caustic soda and other alkalis. The new Alkali Sales division will be headed by **William F. Phillips,** formerly of American Cyanamid Co.

The move is being made as a forerunner to production of caustic soda by Jefferson in the company's new chlorine plant at Port Neches, Texas, scheduled for completion late in 1958.

In addition to Phillips, **Joseph F. Hickey** and **J. Beekman Fish** will also become a part of the Alkali division. **George E. Taylor,** who has been serving as a consultant to Cyanamid, will act in the same capacity for Jefferson.

Phillips, Hickey and Fish have all spent many years in the heavy chemicals field, most of them with American Cyanamid Co. Taylor brings to the new division more than 40 years experience in the alkali business.

TRACERLAB, INC. has announced the addition to its force of **Joseph P. Beyer** as a sales representative with headquarters offices in Los Angeles. Beyer graduated from

For piping systems that can't be anchored, use ZALLEA HINGED EXPANSION JOINTS

Piping systems like the one in this 63,750 bbl/day catalytic cracking unit, one of the world's largest, at Gulf Oil Corp. Girard Point Refinery, have to be entirely self supporting. The entire cracking unit . . . reactor, regenerator and all connecting lines . . . is suspended in a huge structural steel framework, counterweighted to keep the system in balance, and fitted with Zallea Hinged Expansion Joints to provide vital flexibility plus support for the reactor.

In the 150 ft. air supply line, all thermal movement of the piping is absorbed by angular displacement in three 42″ dia. Zallea Hinged Expansion Joints. Start-up air in this line is at 1000°F. Under operating conditions it is delivered at 250°F, 25 psig.

Two 50″ dia. Zallea Hinged Expansion Joints in the spent catalyst line carry fluidized cracking catalyst at 950°F, 13 psig.

Since this cracking unit first went on stream, these Zallea Expansion Joints have given completely trouble-free service.

Process piping of any kind can be fully protected with one or more Zallea Expansion Joints. From the complete Zallea line you can select the expansion joint or combination of expansion joints best suited to your particular problems.

Get the complete story in our new 72-page manual. Write today, on your company letterhead, for your copy of Catalog 56. Zallea Brothers, 890 Locust Street, Wilmington 99, Delaware.

Zallea expansion joints

Zallea Brothers • Wilmington 99, Delaware

World's largest manufacturers of expansion joints

Quoth Sir Galvaknight: **Only Complete PROTECTION is Good Enough**

And the best *complete* anti-rust protection for iron and steel is hot-dip galvanizing. The hot-dip process seals out corrosion on *all* surfaces, as no other protective coating can. Armor-plate your iron and steel with hot-dip galvanizing by the Southwest's largest commercial galvanizers, the Nowery J. Smith Company!

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- Evaporators
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- Ribbon Mixers
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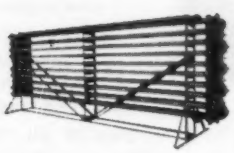
M & L DOUBLE PIPE EXCHANGER

Materials:
All Stainless Steel—Type 316

Physical Dimensions:
90" H x 16" W x 20'9" L
Outside Tubes: 4" O.D. and 11 Ga.
Inside Tubes: 2½" O.D. and 14 Ga.



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50 P.S.I. on both sides

Here is another example, among the thousands of case histories in our files, of how Manning & Lewis clearly and logically interpret customers requirements . . . from original concept to finished quality product.

Both the saving in time and cost resulting from our years of engineering experience are two important factors why more and more manufacturers are turning to M & L.

Why not call on us the next time you need equipment. We design and construct to A.S.M.E. or A.P.I. code or we can build to non-code standards.

Please state *all* conditions of service so that we will be able to handle your inquiry promptly and accurately.

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Menlo College, Menlo Park, Calif. in 1953. An amateur radio operator, he served with the U. S. Marines from 1943-1946 and again from 1950-1951.

CONSOLIDATE ELECTRODYNAMICS CORP. has changed the name of its Electronic Industries division to the Alectra division.

Hugh F. Colvin, president, said the name was changed to eliminate confusion caused by the existence of several other companies with names similar to Electronic Industries. The Alectra Division, formerly Electronic Industries, Inc., Burbank, Calif., was acquired by CEC in June, 1956, and moved to a new Pasadena facility in November.

RAYBESTOS-MANHATTAN, INC., through the purchase of plant and equipment of The Graef Engineering Co., 15010 South Downey Avenue, Paramount, a suburb of Los Angeles, Calif, has established a Pacific Coast division.

Arthur W. Byxbee, formerly sales manager of Raybestos-Manhattan's Plastic Products division, has been appointed general manager of the Pacific Coast division. **Colonel O. K. Graef,** former owner of The Graef Engineering Co., has been appointed plant manager.

HOOKER ELECTROCHEMICAL CO., Niagara Falls, N. Y., has integrated the sales of Oldbury Products into the Hooker chemical sales department under **John S. Coey,** manager—eastern sales. The following ap-

Follow a project from start to finish with—

PROJECT ENGINEERING OF PROCESS PLANTS

By Howard F. Rase, *The University of Texas; and* M. H. Barrow, *Foster Wheeler Corp.* This guide to the practical application of process design principles in industry brings you the "key" man's know-how. It is the only book on plant design written from the viewpoint of the project engineer and in accordance with modern techniques of project organization, planning, and execution. Part one of the work outlines the steps and methods of plant design, and part two discusses the business and legal phases of the project. The principles of equipment design and selection used in a process plant are presented in part three. The final portion describes actual construction operations. 1957. 692 pages. 195 illus. $14.25.

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Suppliers . . .

pointments of Oldbury sales personnel were announced.

Robert B. Boyd, formerly sales manager, Oldbury Products, has been appointed product manager—organic chemicals. **Fred H. Berggren,** who had been assistant sales manager, Oldbury Products, is now product supervisor—chlorate chemicals.

Oldbury sales representatives now reassigned to Hooker sales districts are as follows:

Joseph I. Rue, at Detroit, now reports to Hooker's Chicago office; **John W. Johnstone, Jr.,** at Cincinnati, has headquarters at the Niagara Falls main office; **Charles H. Foster, Jr.,** in Philadelphia, reports to the Philadelphia sales office, and **James T. Whelen,** in New York, will use the company sales office in the Lincoln Building as his headquarters.

THE GIRDLER CO. has named **Edmund W. Dugan** business manager of the Catalyst department. Establishment of the new position and Dugan's appointment were announced by **Dr. Ronald E. Reitmeier,** manager of the department.

Dugan

Dugan was Washington representative for The Girdler Co., and Tube Turns, divisions of National Cylinder Gas Co., Chicago, during the Korean conflict. More recently, he has handled special assignments for the Catalyst department.

From 1947, until his association with Girdler-Tube Turns in 1950, Dugan was sales manager of a steel fabricating firm. From 1939 to 1947, he held posts in sales administration, time study, and dealer business management with the Ford Co. He attended Indiana University.

Mr. Dugan has been nominated for membership in the National Defense Executive Reserve, established by Presidential Order last year. He is a member of several Masonic organizations.

FISCHER & PORTER CO., with main offices at Hatboro, Pa., announced that the company's metropolitan New York sales office is now located at 141 Main Ave., Clifton, N. J. The office was formerly located at 139 Chestnut Street, Nutley, N. J.

A staff of 15 persons occupy the air-conditioned building recently constructed especially for Fischer & Porter by Visscher Brothers Construction Co. **Donald T. Cusack,** divisional manager of the New York area, heads Clifton office.

TRACERLAB, INC., has announced the appointment of **Thomas L. Kelley** as nuclear sales manager. He was formerly sales manager of Tracerlab's Instrument division.

THE GARLOCK PACKING CO., Palmyra, N. Y., announced that **Norman S. Knauss** has joined the company's sales force and has been assigned to the Detroit branch. A 1953 graduate of Miami University, Oxford, Ohio, Knauss holds a B.S. degree in business administration. He was formerly associated with the sales depart-

Panalarm Annunciator pinpoints process "off-normals"

In the process industries and among users of automatic machinery, trouble is minimized when it's caught early. That's the purpose of the Panalarm Annunciator System—a continuous monitor of your process.

One typical adaptation of the modular Panalarm system is engineered to differentiate between the first "off-normal" and subsequent "off-normals" caused by the first. This feature allows instantaneous recognition of the prime source of trouble in a "chain reaction."

Another adaptation is designed specifically for motor start-up and shutdown. It has also been successfully adapted for supervisory control, pump control and programming.

Your Panalarm sales engineer will be happy to make a survey of your requirements to determine whether a Panalarm system can aid productivity and safety in your process. For electrical and mechanical data on standard systems, request Catalog 100B on your letterhead.

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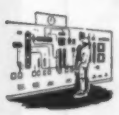
Engineered Information Systems for Industry



Graphic Panels, Control Centers

Panalog Information Systems

Panellit Service Corporation

For more data on advertised products, use Readers' Service Cards, last page.

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TUBE EXPANDERS
AND REPLACEMENTS

top performance
at lower costs

TYPE "FC" WITH BALL BEARING THRUST COLLAR ELIMINATES MARRING, FRICTION ON TUBE ENDS

Installing new tubes or re-rolling old ones . . . Henderer's Tube Expanders combine economy with performance.

Henderer's "FC" Expanders set the standard for general purpose use as well as automatic control devices; meet military specifications.

Expanders also made to order.

WRITE FOR PRICE LIST AND SPECIFICATION BULLETIN 80-E

A. L. HENDERER'S SONS
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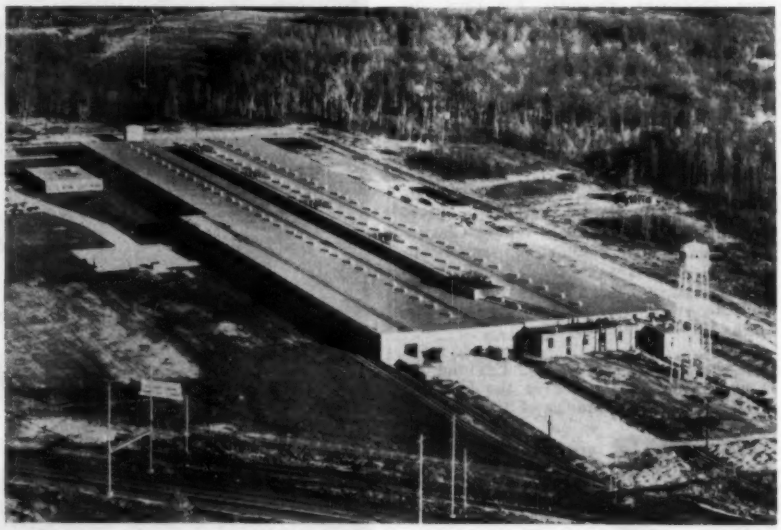
Oldest Original Manufacturer Of Tube Expanders

Suppliers . . .

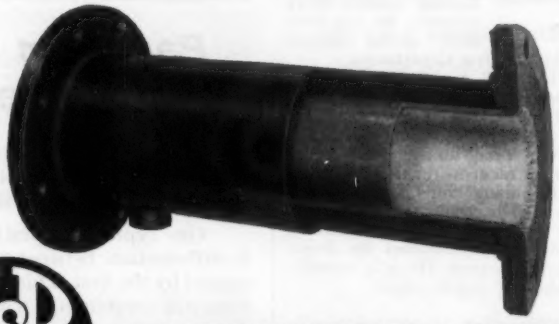
ment of the Lincoln division of the Ford Motor Co.

WHITEHEAD METAL PRODUCTS CO. INC., subsidiary of International Nickel Co. has announced that **Edward W. Lothman,** vice president, has been elected a director of the company. At the same time the company also made known the election of **Richard W. Nuffort** as secretary, **Frank A.**



New Okonite Plant

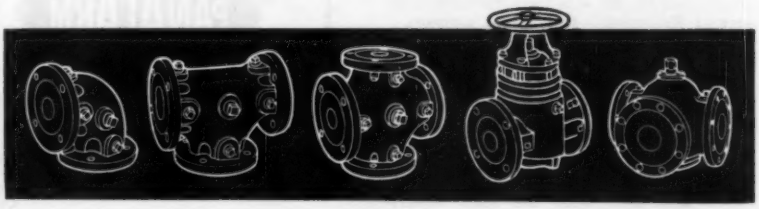
Pictured is the new 446,000 square-foot cable plant of The Okonite Co., located on a 160-acre property in North Brunswick, N. J. The building was originally constructed for a Studebaker assembly operation, but was never used for that purpose. Now, it has been completely revamped to handle heavy processing and manufacturing.



H&B JACKETED PIPE and FITTINGS

● The above cutaway illustrates H & B standard jacketed welded pipe and fitting construction, designed to allow complete jacketing of the product pipe. Special jigs and fixtures enable H & B to insure complete uniformity of the jacket area in relation to the O D of the product line and the I D of the jacket pipe. All H & B jacketed equipment is hydrostatically tested at 450 to 500 p.s.i. H & B welded steel jacketed fittings are ideally suited for process piping of pressures reaching 300 p.s.i. and temperatures up to 750°F. . . . A few of these fittings and valves are illustrated below. For more information send for bulletin J-57.

HETHERINGTON & BERNER INC. • 747 KENTUCKY AVE., INDIANAPOLIS 7, IND.



Suppliers . . .

Fink as treasurer and **John W. Bonnet** as administrative assistant to the president and assistant secretary.

The changes are occasioned by the retirement of **Elmer W. Silver** who has been with the Whitehead organization for over 41 years. Silver is vice president, treasurer, a director and a member of the management committee of Whitehead.

Lothman, who continues as vice president, is succeeded by Nuffort as secretary. Fink and Bonnet were named members of the management committee of the company.

THE PFAUDLER CO., Rochester, N. Y., has announced that **Frank Rosen** has joined the company as a member of the central engineering department. A former design engineer for Westinghouse and General Motors, Rosen is a graduate of Allegheny College. He was with the U. S. Army Air Corps in the Pacific during World War II.

CENTRAL SCIENTIFIC CO. has appointed **A. E. Knox** to the new post of national sales manager. Central Scientific Co., Chicago, is a subsidiary of Cenco Corp.

Central Scientific, the chief manufacturing subsidiary of Cenco Corp., has for more than 50 years been a manufacturer of scientific instruments and laboratory apparatus to industrial, government, and educational research laboratories. Knox, who joined Cenco in 1944, comes to his new position from Mountainside, N. J., where he has been manager of Central Scientific's branch there since 1946.

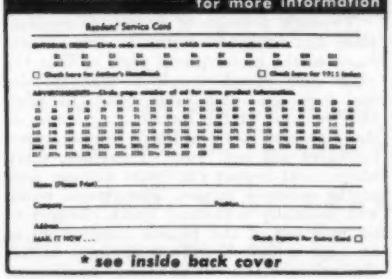
Prior to joining Cenco, Knox had more than 15 years of experience in the scientific instrument and laboratory apparatus field. Born in Houlton, Me., he is a graduate of the University of Maine.

HAYNES STELLITE CO., a division of Union Carbide Corp., has appointed **Robert M. Briney** president.

Briney started with the corporation in 1924 in the Niagara Falls, N. Y., plant of Electro Metallurgical Co., a division of Union Carbide. He has held key positions with that division both in production and development at Niagara, as well as at Alloy, W. Va., and New York. In 1950, he was made vice president in charge of wrought alloy products for Haynes Stellite Co. in Kokomo, Ind., and was transferred to the New York office of that division in July, 1954.

Briney was born in Dayton, Ohio. He received a B.S. degree in chemical engineering from Purdue University in 1924.

use these
READERS' SERVICE CARDS*
for more information



*** see inside back cover**

PETROLEUM REFINER Classified Ads

Petroleum Refiner New Classified Rates

RATES: Regular Classified (undisplayed) set in this size type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. Display Classified ads, set in suitably larger type with ruled border, $12.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. All Classified ads payable in advance. Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

* * * * * * * * * * * * * * * *

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PETROLEUM OR CHEMICAL ENGINEER
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has opening for a graduate Petroleum or Chemical Engineer involving above ground petroleum losses. Applicants should preferably be between 28 and 35 and should have a minimum of 5 years field experience in the production fields, natural gasoline plants or gathering line systems. The position is permanent, located in New York City, with some travel involved. Submit full particulars in resume form together with salary requirements. All replies will be held in strict confidence. Box 272-R, PETROLEUM REFINER, Houston, Texas.

GAS ENGINEER
For Caracas, Venezuela

CHEMICAL ENGINEERING DEGREE. MINIMUM 5 YEARS EXPERIENCE including compressor plant operations, design and operating gasoline plants and gas pipeline work. Capable setting up department when required and working with government representatives.

GOOD SALARY, ALLOWANCES, OPPORTUNITY OBTAIN ADDITIONAL EXPERIENCE AND ADVANCEMENT.

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SOCONY MOBIL
OIL CO., INC.
150 East 42 St., New York, N. Y.

FOR SALE

REFINERY EQUIPMENT

20-Million BTU free compartment furnace, complete with stack. 4" x 5" x 30 ft., 5 and 7% chrome tubes. Furnace is near new condition.

6 x 37 ft. vacuum towers, stabilizer towers and other refinery equipment available for immediate delivery. Inquiries are to be addressed to:

CECO Service Company, Denver Colorado
Telephone EMpire 4-2557
or P. O. Box 65, Aurora, Colorado
or P. O. Box 516, Phillips, Texas

HELP WANTED

CHALLENGING POSITION

We have challenging, responsible supervisory position open in our asphalt research program. Applicant must have considerable experience and background in the formulation and evaluation of asphalt specialty products, supervisory ability, and suitable academic background. Will also assist in technical sales development program. Salary open. Write giving qualifications to: Emmett R. Coley, Supervisor, Technical Recruitment, Lion Oil Company Division Monsanto Chemical Company, El Dorado, Arkansas

SALES ENGINEER WANTED

Well established Eastern manufacturer centrifugal filtering equipment for oil, chemical and process industries seeks man for Southwest to headquarter Houston area. Should have working knowledge hydraulics, high speed machinery, solid liquid separation techniques and process industries methods. Minimum three years sales engineering experience. Chemical Engineer degree or equivalent. Age 30/35 preferable. Good basic salary, bonus and profit sharing, all travel expenses. Excellent opportunity for right man. Send complete resume and earnings record plus comments on your qualifications. Address Box 273-R, c/o Petroleum Refiner, Houston, Texas.

ENGINEERING SUPERVISOR

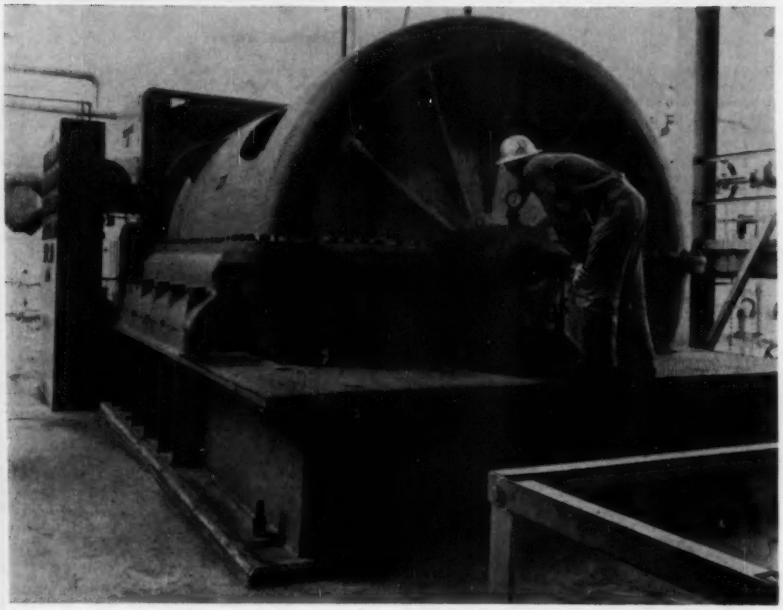
Our continued growth has created an opportunity for a chemical or mechanical engineer in our Engineering Division for a man with a minimum of 10 years industrial experience. Must be capable of supervising a piping and chemical plant layout drafting group. Background in building and ventilation design, process and piping, and equipment design to known safety and insurance requirements is essential. Initial salary commensurate with experience. Advancement based on merit. Location in St. Paul Minnesota provides easy access to nation's outstanding hunting and fishing areas. Please write to—
Technical Employment Department
Minnesota Mining & Manufacturing Co.
900 Bush Avenue
St. Paul 6, Minnesota

Construction Manager

Well established midwest engineering firm has responsible position available for manager of its construction activities. This is a high level management position, requiring capable individual with approximately 10 or more years' experience in the management and supervision of field construction of chemical or petroleum processing units. Salary commensurate with experience and proven ability. Replies will be treated in confidence. Box 274-R, PETROLEUM REFINER, Houston, Texas.

What's New in Equipment . . .

. . . and Manufacturers Literature



Huge Compressor for UOP's Cat Cracker

A recently installed centrifugal compressor delivers 83,000 cfm of air at 47.4 psia to the largest UOP cat cracker ever built. On stream at the Ashland Oil & Refining Co. plant in Ashland, Ky., this cat cracking unit is processing 20,000 bpd. The compressor is driven by one of the largest extraction steam turbines in refinery service. Extracting 150,000 lbs of steam per hour at 155 psig, the turbine is designed for 440 lbs psi, operating at 700 F with 1½-inch hg. vacuum. De Laval Steam Turbine Co.

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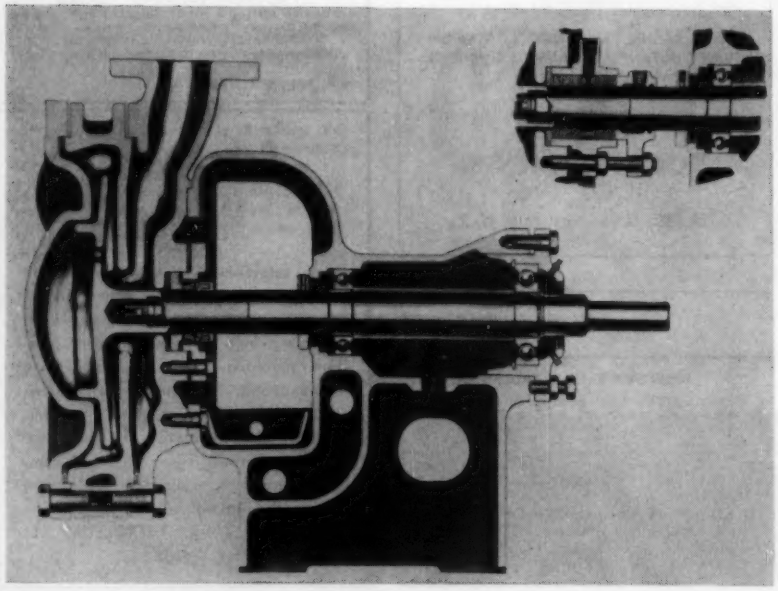

Skim Your Fuel With Floating Suction Unit

Water separation in fueling systems is one of grave concern. Dehydrators and mechanical separators have not provided the complete answer.

The established practice has been to give a settling time between "input" and "output," allowing water and sediment to precipitate out of the fuel prior to use. Therefore, this cleaned fuel can be "skimmed" off, thereby greatly reducing the risk of water contamination.

A "skimming device" has been developed for this purpose. It is a floating suction unit with a new design in the swing joint that has a very low torque value. This design insures complete, automatic flotation and trouble-free operation. EMCO Brass Mfg. Co. Ltd.

Circle E2, green card, last page

Pneumatic Mufflers Control Noise Says New Brochure

An eight page illustrated brochure, "Noise Control" has just been published.

The brochure illustrates with charts and photographs the applications of the new pneumatic mufflers for the elimination of exhaust noises of air operated equipment. The charts illustrate the performance data of the mufflers in frequency and attenuation levels in decibels, loudness and attenuation levels in sones, air flow CFM, noise levels and attenuation levels at various airline pressures.

Three inserts accompany the brochure. One shows muffler construction by model and its dimensions and configurations, and the second is an air flow graph. The third is a price list. Allied Witan Co.

Circle E3, green card, last page

Glass Pump Withstands Effects of Corrosives

A glassed centrifugal pump which will withstand the effects of most corrosives used in the petrochemical industries has just been developed.

The glassed pump is completely inert to all common acids except hydrofluoric. Even at high temperatures, all acids except hydrofluoric and concentrated phosphoric leave working surfaces unaffected. Glass surfaces of the pump are also immune to the corrosive action of all alkalis up to pH 12 and temperatures up to 212 F.

Through a series of successive applications and firings, the glass is permanently fused to the metal pump parts so that the glass and metal interlock mechanically and form an inseparable bond. In addition, because of the interlocking action of the glass and metal at fusion temperatures, fractures will not "run." Therefore, sharp mechanical impact can cause damage only at the point of impact. The glassed pump will normally withstand quick changes of temperature of the liquids handled up to at least a 200 F differential and higher depending upon operating conditions.

PROPER TOOLING

EFCO's Four Point Program Provides:

- service-proved engineering design
- guaranteed job ratings
- complete fabricating facilities
- technical service before, during and after installation

One reason that Efco does it *right* is its many years of experience in designing and fabricating heat-exchangers for the wide range of temperatures and pressures represented by ethylene plants and platinum catalyst reforming units. We are recognized specialists in handling all grades of carbon, alloy, and stainless steels, nickel, aluminum, and special low-temperature materials.

ASK OUR GULF COAST CUSTOMERS — THEY KNOW US WELL

Write for General Catalog

EFCO HEAT TRANSFER EQUIPMENT

Engineers and Fabricators, Inc.

P. O. BOX 7395 **HOUSTON 8, TEXAS**

EFCO

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For more data on advertised products, use Readers' Service Cards, last page.

Write for your CATALOG NOW!

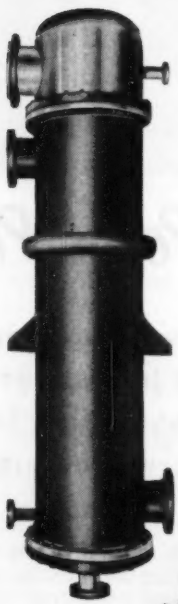
DOYLE & ROTH
VAPOR CONDENSER

STANDARD
STAINLESS STEEL

MODEL— VT

D & R passes on to you the economies accruing from its standardization program. Starting with engineering and following through on construction, economies are substantial. Materials are purchased to rigid specifications and standard components are stocked. ASME standards govern fabricating procedures.

Standardized equipment PAYS . . .
★ LOW FIRST COST,
★ PROMPT SHIPMENT,
★ EASILY REPLACEABLE PARTS *obtainable from stock.*



Send Coupon Today!

DOYLE & ROTH Manufacturing Co., Inc.
140 Twenty-fourth Street, Brooklyn 32, N. Y.

Please send further information
and details on D. & R. Model VT-Vapor Condenser.

FIRM NAME .....
INDIVIDUAL .....
ADDRESS .....
CITY ..... ZONE ..... STATE .....

New Equipment . . .

Since glass has no catalytic or contaminating effect in any known case, there is no possibility of side reaction or contamination. While many polymers, plastics and synthetic rubbers will cling readily to metal surfaces, even when highly polished, they will not adhere to glass. Goulds Pumps, Inc.

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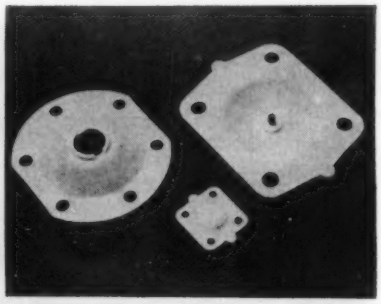


Molded Diaphragm Shields For Corrosion Resistance

Seven sizes of standard molded Teflon and Kel-F diaphragm shields to fit diaphragm valves in the three-inch and under size range have recently been marketed. These shields are installed over a rubber diaphragm to provide corrosion and heat resistance, and are unaffected by all chemicals normally found in industry. They are attacked only by molten alkali metals, chlorine trifluoride, and fluorine at elevated temperatures and pressures. They are not affected by alkalis in any concentration nor will they swell or change weight when boiled in solvents or acids. Temperatures of 350 F. and higher are possible where low line pressures exist, i.e., approximately 30 pounds psi. The Garlock Packing Co.

Circle E5, green card, last page

Gearmotors and Packaged Drives Booklet Available

A new 8-page booklet on gearmotors and package drives is now available. Horizontal, vertical, right angle, open, enclosed, explosion-proof, a-c and d-c units are illustrated with their respective reduction ratios, and output speeds. The gearmotors are designed in accordance with AGMA classes I, II, III and range in speed from 7.5 to 780 rpm. Westinghouse Electric Corp.

Circle E6, green card, last page

Bulletin Tells of General Automatic Control Theory

A new bulletin on pneumatic control instruments, featuring more than ten pages of general automatic control theory has recently been published.

The 44-page bulletin describes in simplified terms and illustrations the basic concepts of narrow band, proportional, reset, derivatives, and reset plus derivative control actions. Also covered are selective control, cascade control, and ratio control.

Completing the bulletin are descriptions

Among the scores of refinery installations—

THE DEMPSTER DUMPSTER® SYSTEM

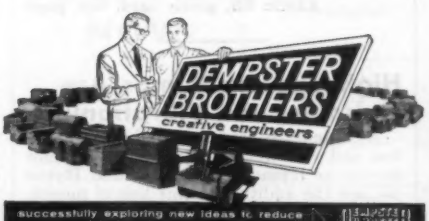
Performs Several Important Materials Handling Jobs at... THE TEXAS COMPANY

As shown here the Dempster-Dumpster System handles waste materials, liquids, heavy wastes, etc., at The Texas Company, Port Arthur, Texas, refinery. Photos show you a sample of the different types of Dempster-Dumpster Detachable Containers among the many that are in use at this plant.

One truck-mounted Dempster-Dumpster, with only one man, the driver, serves scores of Dempster-Dumpster Detachable Containers, regardless of size or design, and handles each, one-after-another. This efficient system has been in operation at the Port Arthur plant since 1952. We are proud that our Dempster-Dumpster System has been called on to contribute to the efficient plant operation of this refinery.

You, too, can expect to make substantial reductions in materials handling costs with the Dempster-Dumpster System. Write us today for complete information and literature. Manufactured by Dempster Brothers, Inc.

THERE IS A DEMPSTER-DUMPSTER DETACHABLE CONTAINER AVAILABLE OR THAT CAN BE BUILT TO SUIT THE MATERIAL — be it solid, liquid, dusty, combustible, high temperature . . . waste or salvable, raw or finished product — and each, regardless of size up to 21 cubic yards or capacity up to and over 36,000 pounds payload, can be handled by one truck-mounted Dempster-Dumpster with only one man, the driver! Savings are tremendous!



successfully exploring new ideas to reduce your materials handling costs with the.... DEMPSTER DUMPSTER SYSTEM

DEMPSTER BROTHERS, 587 Dempster Building, Knoxville 17, Tennessee

For more data on advertised products, use Readers' Service Cards, last page.

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Write for SOLVAY Aluminum Chloride literature and prices. For specific information, include your question. No cost!

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New Equipment...

of the features of the company's line of pneumatic recording and indicating controllers. Also included is complete information on sensing elements used with the instruments, for measuring and controlling such variables as temperature, pressure, humidity, flow, density and specific gravity, liquid level, and pH. Final control elements and accessories are listed. The Bristol Co.

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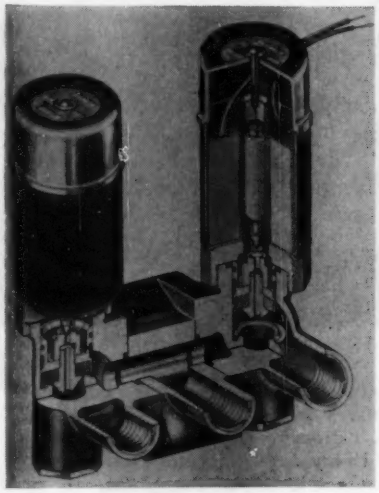


3-Way Flow Control With Unusual Solenoid Valve

A new 3-way double solenoid valve provides unusual flexibility for 3-way flow control applications. The new valve is available in three assemblies for mixing, divided flow and cylinder control operations.

As a mixing valve, the new valve has two inlets and a common outlet and it can be supplied with oversize outlets to provide maximum flow.

For divided flow, the valve has one inlet and two outlets. Inlet can be supplied larger than individual outlets for maximum flow.

As a cylinder control valve, the unit has an inlet, cylinder and exhaust connections. An optional check valve maintains pressure on cylinder in case pressure source fails.

The valve is bubble tight and may be used at specific pressures ranging from 5 to 1000 psi with both pistons normally closed and at 5 to 500 psi with either or both pistons normally open. It is available in one-half-inch and three-quarter-inch pipe sizes. Atkomatic Valve Co.

Circle E8, green card, last page

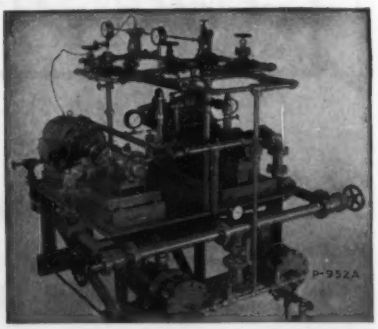
High Vacuum Pumps Are Noiseless and Vibrationless

A completely redesigned line of noiseless and vibrationless high vacuum pumps known as Hyvac 2, Hyvac 7, and Hyvac 14, are the addition to this line of pumps.

The well-known principle of gas ballast control is offered as standard equipment on Hyvac 14, and is optional on Hyvac 7. A vacuum pump employing this feature

COMPLETE RANGE OF SIZES AND MODELS IN BOTH MEDIUM AND HIGH PRESSURE TYPES

MORE COMPACT THAN EVER . . .



P-952-A—Steam Turbine and Electric Motor drive gives flexibility in this compact Model P-ES2H size No. 25 unit.

NATIONAL AIROIL

FUEL OIL PUMPING AND HEATING UNITS

NATIONAL AIROIL Fuel Oil Pumping and Heating Units are specially designed to prepare, for combustion, all grades of fuel oil including No. 6 or Bunker "C" Oil and residuums. They will draw fuel oil from above ground or underground tanks, preheat it to proper constant temperature and deliver it to Oil Burners at an even pressure, best suited for the burners. Our Fuel Oil Pumping and Heating Units are the result of years of experience. They come completely equipped ready for steam, exhaust, condensate, oil suction, oil return, and electrical connections. All valves, regulators, etc., are readily accessible. The piping arrangement is easily understood. These compact, space-saving units are available in a range of sizes and models in both Medium and High Pressure types. For complete details, write for our Bulletin 40—very interesting and informative.

OIL BURNERS and GAS BURNERS for industrial power, process and heating purposes
STEAM ATOMIZING OIL BURNERS
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LOW AIR PRESSURE OIL BURNERS
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GAS BURNERS
COMBINATION GAS & OIL BURNERS
FUEL OIL PUMPING and HEATING UNITS
FURNACE RELIEF DOORS
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Multiple Port, 100% Pipe Area or Venturi

Diamond Port or "V" Port for Throttling

Round Port 100% Pipe Area

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offers you one source for

ALL TYPES OF PLUG VALVES

ALL TYPES OF PORT OPENINGS

Homestead Cam-Seald Tapered Plug Valve Positive Metal to Metal Seal

Homestead Lubricated Plug Valve High Pressure Chemical Seal

Homestead Lever-Seald Tapered Plug Valve Positive Seal Without Lubrication

Name the type of valve you need in the metal or alloy you require with the port opening you want—and we can furnish it. Or if you have a valve problem that defies solution, write us, naming the fluid, concentration, temperature, pressure, valve size, function and frequency of operation. We will be happy to recommend the best and most economical valve for your service conditions.

For complete information on Homestead Plug Valves

MAIL THE COUPON NOW!

Please send me information on the following Homestead Plug Valves:

☐ Lubricated ☐ Lever-Seald ☐ Cam-Seald

Name_____ Title_____

Company_____

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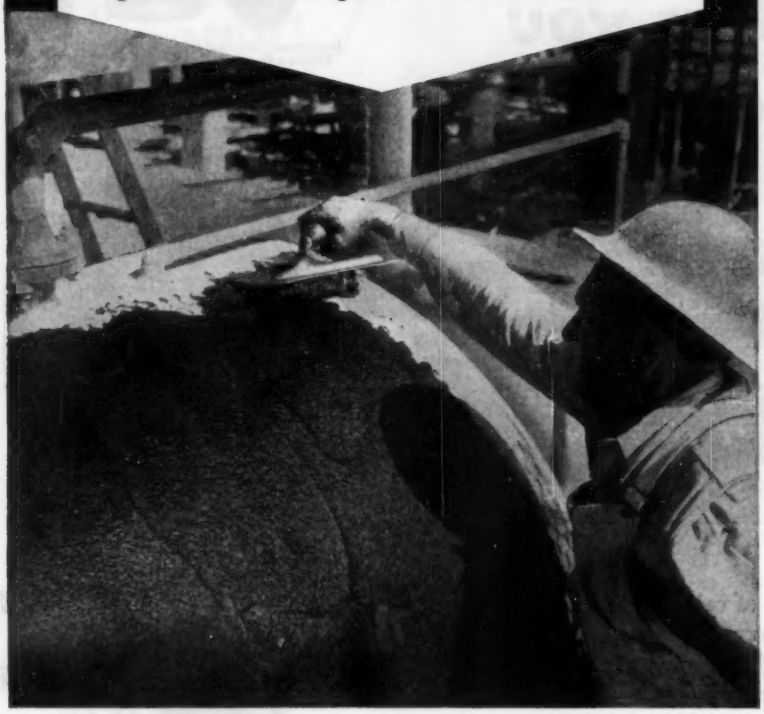
P.O. Box 45 *"Serving Since 1892"* Coraopolis, Pa.

Laykold® WEATHERCOAT
protects exposed insulation



INSULATION on towers, tanks and exchangers must be kept DRY. If moisture gets through, the efficiency drops.

Modern refinery and plant design places many major insulated vessels "in the open." You can maintain the efficiency of your insulation with easy-to-apply Laykold Weathercoat.

Weathercoat is a fibrated asphalt-base material of easy troweling consistency that dries to a black, remarkably tough and tenacious coating. A majority of the leading refineries are regular users of Weathercoat.

A new product: Mastic Weathercoat, a bodied material, for use wherever economy demands the application of a *single*, thick layer.

Write today for our free illustrated brochure, entitled "Laykold Weathercoat for Insulation Protection."

American Bitumuls & Asphalt Company

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St. Louis 17, Mo. · San Juan 23, P.R. · Oakland 1, Calif.
Perth Amboy, N.J. · Cincinnati 38, Ohio · Tucson, Ariz. · Portland 7, Ore.

New Equipment . . .

is able to pass water and other condensable vapors through the pump and exhaust them with virtually no internal condensation. Gas ballast pumps are especially suitable in the fields of vacuum distillation, vacuum drying, vacuum casting of metals, vacuum ovens, and in other applications where condensable vapors may be present.

A special feature of the new line of pumps is extremely simple internal design. There are fewer moving parts, all machined to close tolerance. If maintenance becomes necessary, it can be done on the bench, eliminating the costly down-time required to send the pump back to the factory for repairs. Central Scientific Co.

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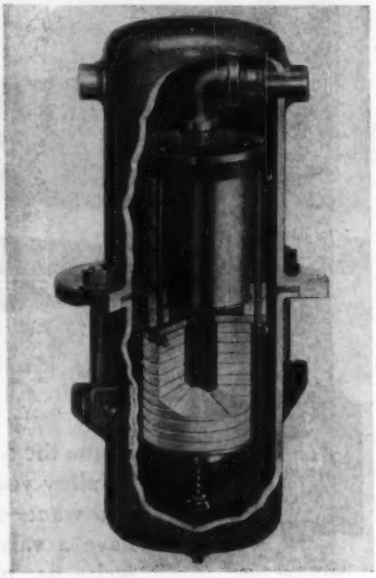

New Filter Absorbs And Adsorbs Liquids and Vapors

The Du Phase, a dual functioning filter, designed to remove small quantities of true vapor as well as liquids from compressed gases, is now being marketed.

It will also remove contaminating vapors from gases which might be injurious to final products.

Du Phase filter uses absorption and adsorption principles. The compressed air or gas being filtered first travels through a conventional set of absorption pads. Then, before leaving the filter housing, it rises through a metal canister or cartridge containing an adsorbent such as activated carbon, or silica gel.

Adsorption takes place in the canister. The adsorbent has a large surface area. The hard granules are porous to the extent that each pound offers an effective drying area of two million square feet.

True vapor consists of molecular particles so immeasurably small they will penetrate a strictly absorption-type filter. The problem posed by this situation is solved by collecting the tiny particles into multiple molecular sizes. The enlargement is done by a phase of condensation, the function of the adsorbent. Once the vapor has condensed, it adheres in an extremely

KING SIZE

This giant 37 ton Cat Poly Reactor is one of 4 units shipped to a large petroleum refinery in the State of Washington. It is 4'-3½" in diameter by 32'-0" long and has a 1 3/16" thick shell. Each of its 8" thick heads is attached to the shell channel with 28 special alloy stud bolts 2¾" diameter by 15¼" long having nuts 4¼" across the flats. Into the 5¾" thick tube sheets 190 tubes, 2½" O. D., No. 5 gauge and 30'-0" long, are rolled and seal welded. Designed for 1,230 lbs. pressure on the tube side, the reactor was completely X-rayed and stress relieved.

Vogt, a leading builder of shell and tube reactors for poly plants, has the competently skilled personnel and modern mechanical facilities with which to provide heat transfer equipment for the most exacting services in petroleum refineries, chemical plants, and related industries.

Reactors ...by Vogt

A bulletin describing the wide range of heat transfer equipment built by Vogt is available upon request.

Address
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HENRY VOGT MACHINE CO., LOUISVILLE, KENTUCKY

BRANCH OFFICES: NEW YORK, CHICAGO, CLEVELAND, DALLAS, PHILADELPHIA, ST. LOUIS, CHARLESTON, W. VA.

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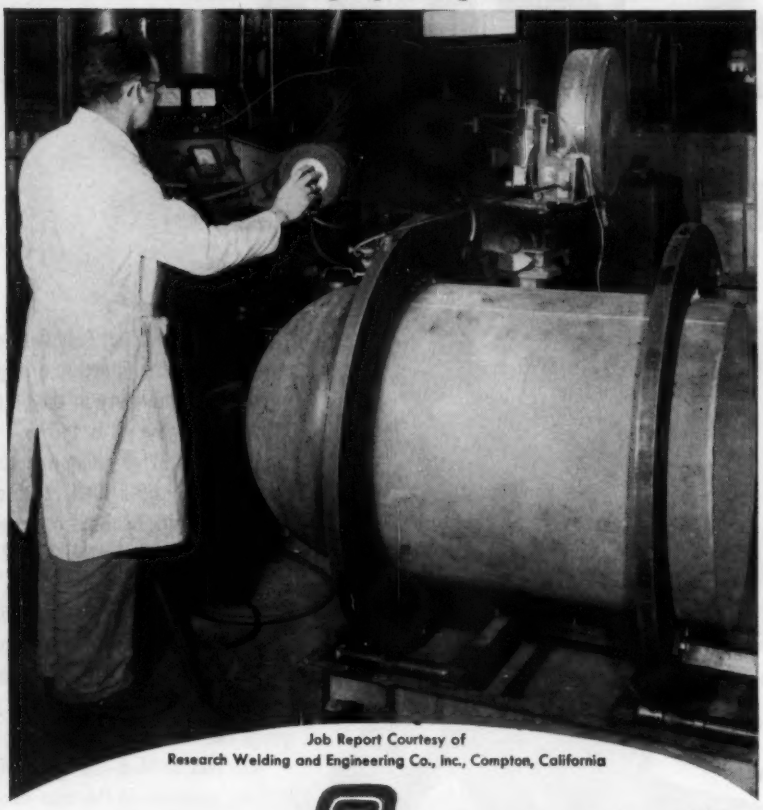
Weld from one side only . . . Get X-ray quality welds

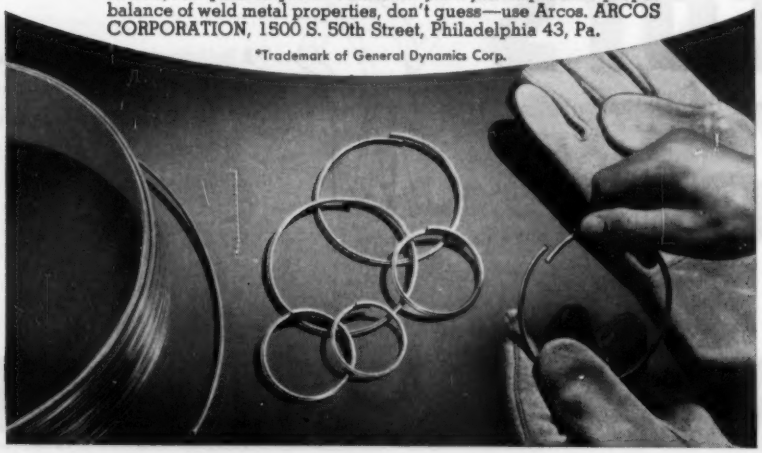


Job Report Courtesy of
Research Welding and Engineering Co., Inc., Compton, California

USE THE ARCOS EB* WELD INSERT

This welded missile tank had to weigh less than 600 pounds and yet contain air under pressure of 3,000 p.s.i. Arcos EB* Consumable Weld Inserts were used in automatic inert gas arc welding of the dished heads to the tank body. The inserts saved weight by eliminating back-up rings. They also allowed welding to be done conveniently from one side only and produced 100% x-ray quality root passes. Chromenar CMV coiled wire for submerged arc welding was used to complete the welds. After heat treatment the welds matched the base metal, with tensile strength in excess of 200,000 pounds p.s.i. Whenever your job requires a proper balance of weld metal properties, don't guess—use Arcos. ARCOS CORPORATION, 1500 S. 50th Street, Philadelphia 43, Pa.

*Trademark of General Dynamics Corp.



New Equipment . . .

thin layer to the thousands of microscopic pores with which the adsorbent is completely permeated.

The canister or cartridge life is approximately 150 hours. Dollinger Corp.

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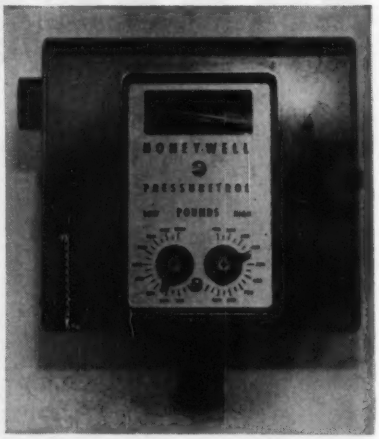


Industrial Pressure Switch Suitable For Corrosives

A new high-pressure industrial switch designed for applications involving corrosive mediums has just been introduced.

Especially suited for chemical and oil refinery operations, the switch has an operating range of 100 to 1000 psi.

It is available in three models. One model (the P428A) completes an electrical circuit on a drop in pressure, another model (the P428B) does this on a rise in pressure and the final model (P628A) incorporates a single-pole, double-throw electric switching action. The three switches are used to either limit or to control pressure of air, gas, oil, etc.

A stainless steel bourdon tube switching element is provided for use with corrosive mediums. Other features include visible viewing of mercury switch position, heavy duty case, and fingertip control point adjusters. Minneapolis-Honeywell Regulator Company.

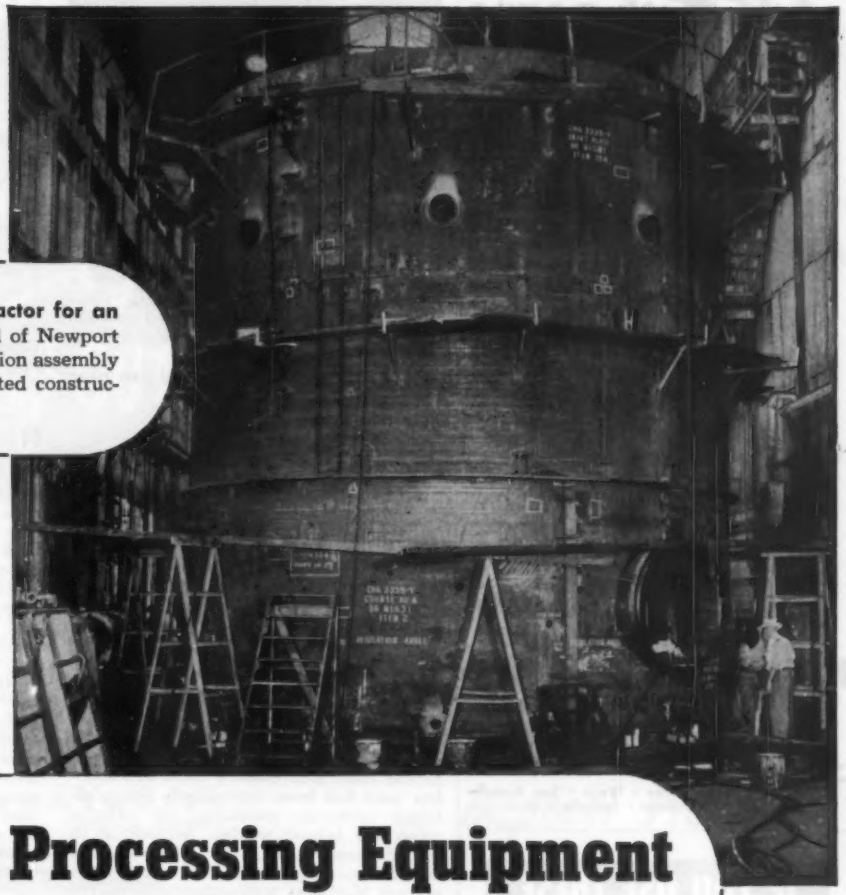
Circle E11, green card, last page

First Zirconium Welding Fittings Have Been Forged

What are believed to be the first welding fittings of zirconium and Zircaloy 2 have just been forged.

The fittings have an outside diameter of 1.5 inches and a .065-inch wall.

Designers of piping in the chemical and



Course number four of a reactor for an overseas oil refinery. Typical of Newport News plant methods, the precision assembly of this unit in the shop expedited construction of the reactor in the field.

Petroleum Processing Equipment

...Built by Specialists in Metal Fabrication

Careful attention to detail characterizes the work of Newport News craftsmen...

They've fabricated millions of tons of steel including corrosion-resistant alloy, clad and other special steels for many diverse industries.

Newport News handles the job exactly as you want it done, for maximum results per dollar invested.

Specialized production techniques, advanced plant methods and a complete range of facilities along with many special purpose machines contribute to the excellence of Newport News fabrication.

Let us bid on equipment for your present or future projects. Learn how Newport News can help you...send for our booklet entitled "Facilities and Products." It's yours for the asking.

Newport News Shipbuilding and Dry Dock Company

Newport News, Virginia

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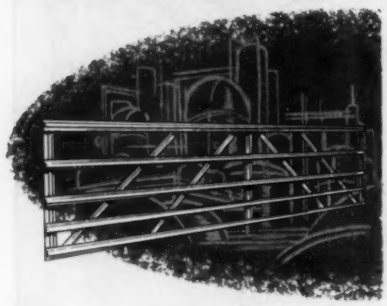
SOLVE YOUR GATE PROBLEMS FOREVER



Life-Time Gates have the strength, durability, efficiency, safety and economy that solve your gate problems permanently. The patented design features a rigid frame of rolled-edge corrosion resistant aluminum or galvanized steel. Specially designed hinges and latches are practical, compact and rugged. Order the original and genuine Life-Time Gate from . . .

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New Equipment . . .

nuclear fields are specifying zirconium and Zircaloy 2 in increasingly large quantities where severe corrosion conditions are met.

Laboratory tests and field experience show that these materials have a combination of desirable properties, and that they can effect important economies when properly applied. In addition to providing excellent resistance against the attack of a wide variety of corrodents they have a very low thermal cross section (0.18 Barns), and possess relatively good strength up to moderately high temperatures. Tube Turns.

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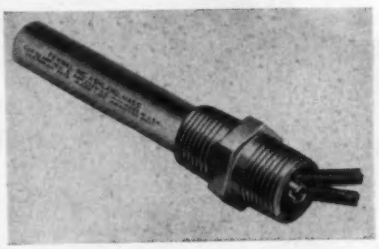

Stainless Steel Thermostat For Corrosive Applications

For corrosive applications a new thermostat fabricated entirely from 316 stainless steel has been introduced. For additional corrosion resistance, all exterior joints are heliarc welded. Because of its special construction, the stainless steel unit is especially suited for service in 5 percent H_2SO_4 at temperatures up to 120 F (or in higher concentrations at lower temperatures), acetic acid vapors, halide solutions, alkaline solutions, and other materials to which 316-type stainless is resistant. It will provide excellent service in all types of photographic solutions.

The Thermoswitch unit is supplied with coupling-head mounting having a ½-14 pipe thread for direct threading into a tank or pipe wall. Contacts open above the control setting. Control temperatures are adjustable over a range of —100 to +400 F, and short-time overshoot by as much as 100 degrees will not affect reliability. Current rating is 10 amps, 115 volts AC, or 2 amps, 115 volts DC. The cartridge is ⅜-inch in diameter, and has an immersed length of 3 inches. The thermostat will control within 2 degrees F in a well-designed system. Fenwal Inc.

Circle E13, green card, last page

New Furnace Manual Describes Heater Design

The 1957 Edition of the Isoflow Furnace Manual has just been published. The scope of the 116-page manual has been broadened by the inclusion of data from over 1650 additonal installations. While written primarily for operators of Petrochem-Isoflow furnaces, the manual will be of benefit to plant designers, operators and instrument men dealing with any type of heater.

Nine different types of Isoflow furnaces are described and illustrated, each one designed to meet specific conditions of service, pressure and efficiency. All types have the upright cylinder structure with integral self supporting stack, and features proper fire box proportions, a reradiating cone for even heat distribution and burners specifically designed to the requirements of the furnace. Petro-Chem Development Co., Inc.

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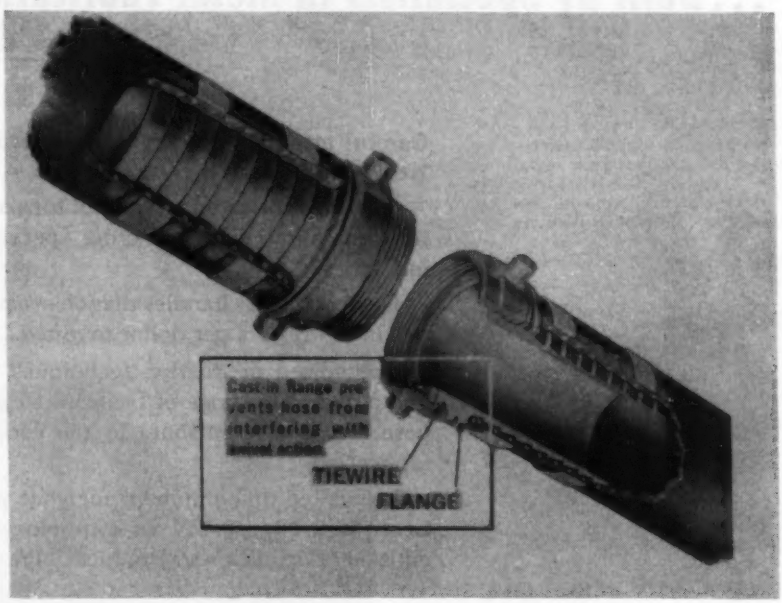
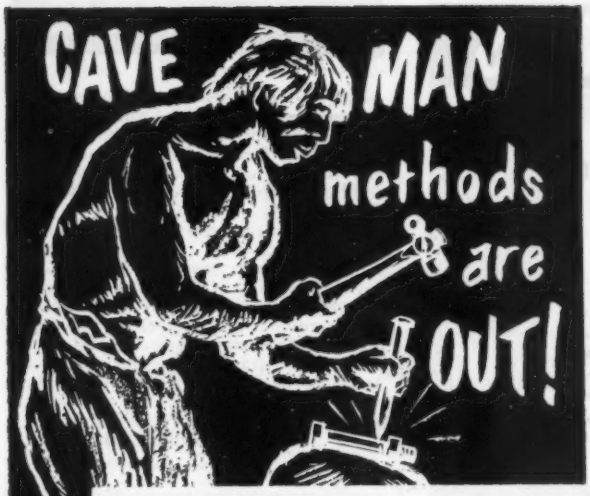


Liquid Hose Coupling Doesn't Injure Hose

A new full flow coupling is specially designed for handling liquid products under pressure and is available in special designs and metals to meet individual requirements.

Unique feature of this coupling is the simple method by which the swivel nut is secured to the shank. A tie wire is built in to secure the swivel nut thereby elimi-



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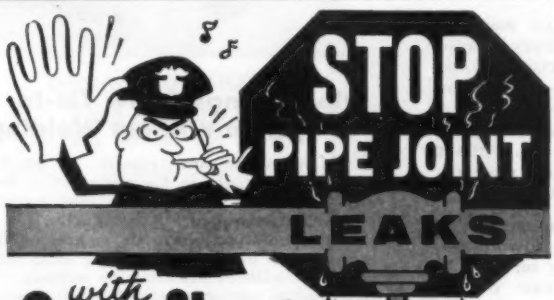

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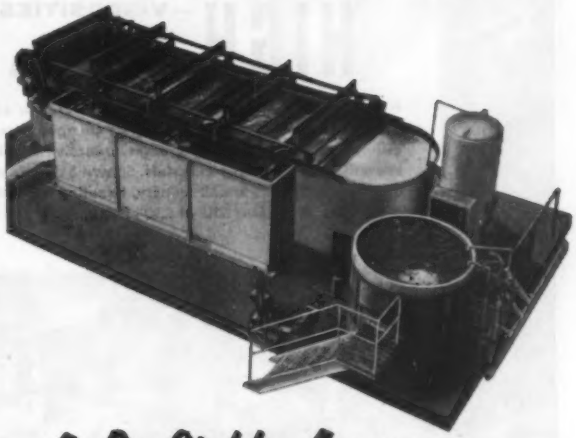

A Profitable Answer to Refinery Waste Disposal Problems

Refinery waste disposal problems are quickly and conveniently solved with Bulkley, Dunton Colloidair Separators. These units, designed and engineered to help meet the usual standards established for process flows by government authorities, remove and recover oil, as well as suspended solids, from flows and return effluent for reuse or disposal. They're built for maximum operating efficiency and minimum space requirements.

If you have a pollution or waste recovery problem, a Bulkley, Dunton engineer will be happy to survey your needs and make recommendations. Bulkley, Dunton can also supply a pilot plant for on-the-job tests on your waste flow, if required.

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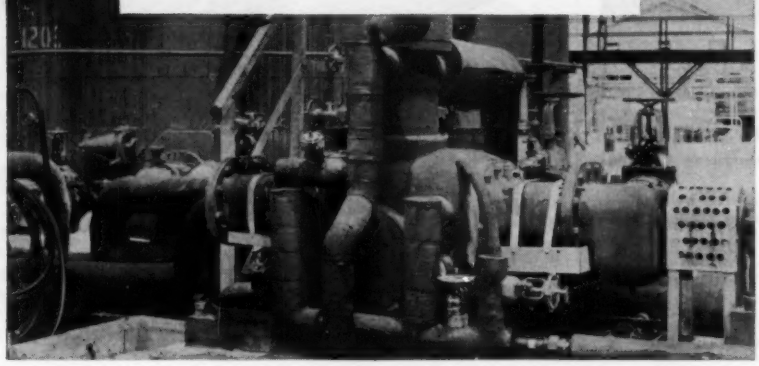
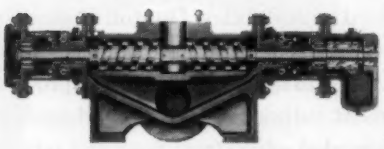
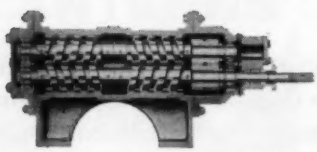


Sier-Bath SCREW PUMPS



External Gear and Bearing Bracket Type for non-lubricating liquids and semi-liquids



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New Equipment . . .

nating the necessity of cutting expensive hose when replacing worn nut. To replace worn nut simply cut open with hacksaw, spread and remove. Replacement of nut and tie wire only therefore, involves an additional economy over the single-piece type shanks.

Non-slip corrugated shank gives positive hose gripping area (sufficient for three three-fourths-inch bands or clamps) without injuring hose. Cast in flange prevents hose from interfering with swivel action; acts as cushion for hose end to rest upon, thereby eliminating any possibility of swivel action fraying hose fabric material. Available in two-inch size with a hex swivel nut and a three-inch size with a pin lug swivel nut. Universal Valve Co.

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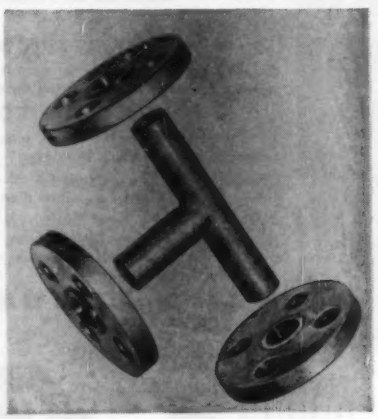

Pipe Fittings Allow Tie-In To System Without Welding

Maintenance and repairs to process piping, especially in hazardous areas, frequently requires costly down time because of welding required.

It is now possible to tie in new equipment and break into existing lines and headers without resorting to welding.

Easy to perform expanding of pipe or stainless steel fittings into insert flanges minimizes time "out of production" for your lines and gives strong leak-proof joints.

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The "tangential" feature (extra straight section) on all Speedline formed fittings permits attachment of insert flanges by simple expanding operation. There is ample clearance to permit flanging of one or all ports of fitting without fouling. Horace T. Potts Co.

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service on which synthetic rubber compounds and natural rubber do not maintain their rubber characteristics. The silicone rings resist oxidation, withstanding indefinitely continuous exposure to hot air and temperatures up to 300 F, and in most applications will withstand for long periods of time, exposure to dry heat at temperatures from 300 to 500 F. The Garlock Packing Co.

Circle E17, green card, last page

Turbine Flow Meter Gives Precise Flow Measurement

A catalog on the turbine flow meter, a device for the precise measurement of liquid flow has been issued. Inserted directly into process piping, the meter can measure the rate of flow of a variety of liquids having flows of from less than one gpm to more than 2500 gpm. Accuracy of the meter is high; ± ½ percent of instantaneous rate under production conditions.

The meter is so designed that mounting in any position has no effect on the flow coefficient. Special thrust plates, installed in both front and rear hub assemblies, guard against the effects of reverse flow. Fischer & Porter Co.

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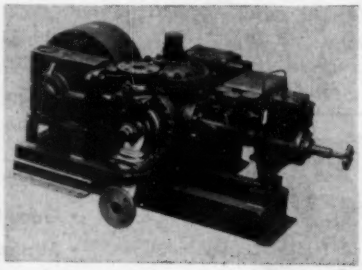

Glandless Diaphragm Pump Works at High Pressure

Glandless Piston Diaphragm Pumps operating on high pressures are now available to meet special requirements in the petrochemical industry.

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An amazing increase in service life for tubing and pipe subjected to highly corrosive agents in oil refinery and petrochemical plant piping systems and heat transfer equipment is available in the form of nickel alloy coatings. After application, the coating is fused by heating in a reducing atmosphere, into a protective nickel alloy cladding. The coating, or cladding, actually forms an interface with the base metal, adhering to it so tenaciously that no evidence of flaking, peeling or exfoliation is encountered, even after 180-degree bends, so often required in return-bend heat exchanger tubing, are formed of the treated units.

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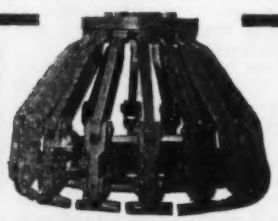
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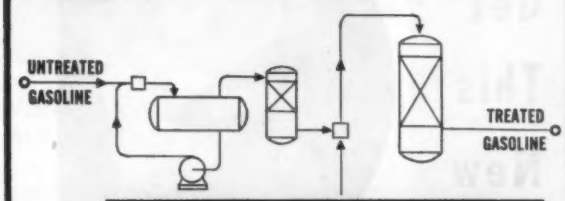

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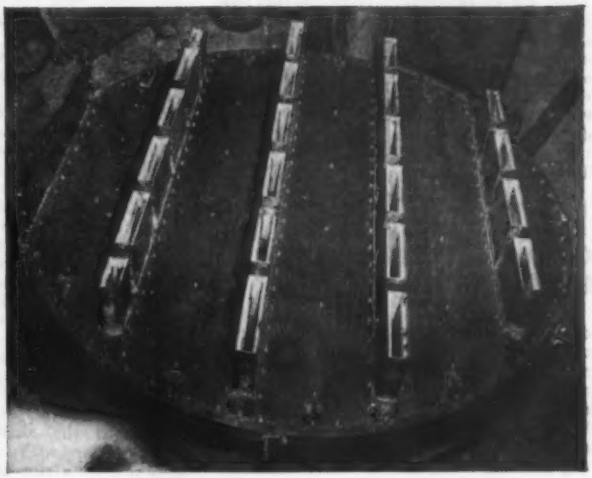

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New Equipment . . .

heat resistance to temperatures as high as 1150 F., it prevents scaling of the base metal, an important consideration in the case of refinery heater tubes. Furthermore, coated areas can, when properly welded, suffer no loss of corrosion resistance in the weld-affected area, fabrication of heat transfer units and piping systems having dependable, corrosion-resisting properties throughout should be greatly simplified. Tube Reducing Corp.

Circle E20, green card, last page

Cable Tester Detects Hidden Flaws In Cables

Continuous research has brought production of the "perfect cable" much closer to reality with the development of an entirely new method of testing high voltage rubber-insulated cable. This revolutionary, non-destructive test method has become known as the "Gooding Test Train," so named for the company's chief research engineer.

The "Gooding Test Train" is significant to cable users because it is able to detect and locate imperfections not always revealed by ordinary test methods such as high voltage spark tests, extra high voltage a-c and d-c tests and "full reel" corona tests. While such flaws, when undetected, might not cause immediate or early failure, they may be the cause of some of the "unknown" outages which occur after a few years service.

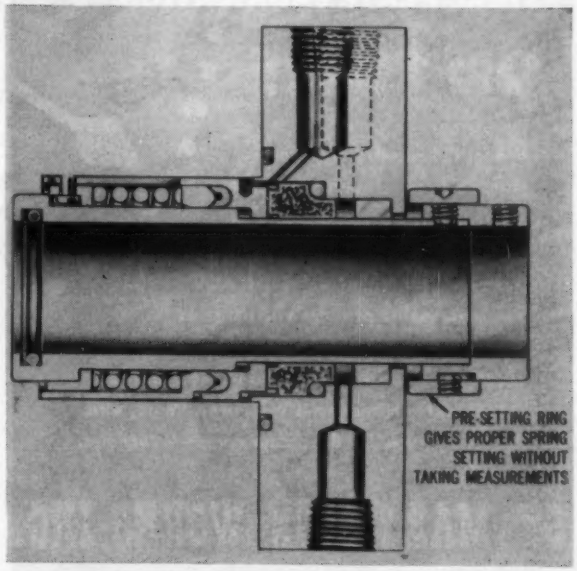
By such thorough testing, it is possible eliminate previously unknown imperfections that might lead to premature failure. Also, studies of these defects help to identify their cause and alloy preventive measures to be taken. The end result is a longer-lived, more dependable product that will assure greater circuit security. The Okonite Co.

Circle E21, green card, last page

Perfect Mechanical Installation Is Now "Built In"

Perfect mechanical seal installation without measurement is now "built in" with this pre-setting ring feature. Anyone with simple hand tools can install or replace mechanical seals with pre-setting ring without taking measurements or referring to installation drawings.

This development provides a seal assembled as a cartridge unit ready for installation. No field fitting is required. The pre-setting ring is attached to the shaft sleeve collar with a set-screw in a slot of controlled length. The "packaged" seal is slipped onto the shaft and into the stuffingbox. The seal flange is bolted to the stuffingbox and the shaft sleeve collar fastened to the shaft. The pre-setting ring is then moved the length of the set-screw slot and locked in place. This places the seal in precise running position with the spring compressed to its proper tension. Byron Jackson Pumps, Inc.



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VIKING ROTARY PUMPS

• Cut-Away View Showing Viking's Gear-Within-A-Gear Principle

The unique and unusually simple construction of Viking Pumps . . . with only two moving parts . . . assures you of long, easy-maintenance operation with all grit-free liquids.

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Six Booklets Describe Insulation Application

A set of six specifications covering the application of Foamglas insulation for use on industrial equipment and piping is now available.

Each booklet contains tables of suggested thicknesses of insulation to be applied, detail drawings of installation procedure, insulation supports, and recommended finishes.

The titles of the booklets are as follows:

Low Temperature Equipment and Piping (Below 70 F.)

Medium Temperature Equipment and Piping (70 F to 212 F.)

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Dual Temperature Equipment and Piping (—300 F to 400 F.)

Underground Piping

Insulation on Spheres (Temperatures between 70 F and —25 F.) Pittsburgh Corning Corp.

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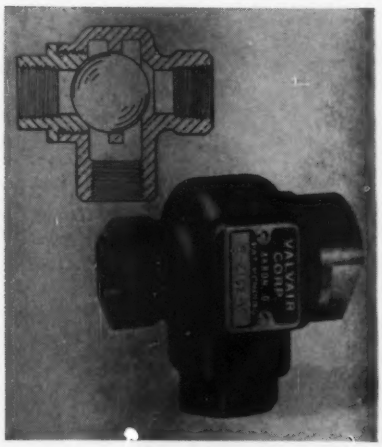

Valve Allows Switch from Automatic to Manual

A new directional valve, which affords instant switch-over from automatic to manual control of diaphragm-operated valves, cylinders and similar devices, is now announced.

The new valve, installed as a tee in the inlet lines, permits manual take-over from automatic control, or control from two different sources, whenever desired. It also can be used to prevent inter-mixing of supply when two gasses or liquids are being delivered alternately to a tank or container. Completely automatic in operation, the directional valve can be substituted for a dual top valve, the manufacturer says.

Simple in design, the new valve consists of a captive Hycar ball which shuttles between two seats in the Navy M bronze valve body. When pressure is applied to one port, the ball shifts to, and seals, the opposite port.

Suitable for use with air, oil, water or media compatible with Hycar and bronze, the directional valve is available with ¼ and ⅜ N.P.T. ports. Net open area between seat and ball is equal to transverse area of ⅜ standard pipe. Valvair Corporation.

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Liquid Detergent Reduces Clogging In Steam Cleaners

A new liquid detergent designed for use in solution lifting steam guns and self generating steam cleaning equipment, has just been introduced.

Developed to simplify the preparation of steam cleaning solution and to reduce the clogging of coils in self generating equipment, it will handle a wide variety of steam cleaning operations ranging from light to medium-heavy duty. It is said to provide effective soil removal at concentrations of one to two ounces to each gallon of water as delivered by the gun. Used as recommended it is claimed to be safe on steel, brass, and magnesium, and to have no effect on painted surfaces. Its solutions have a pH of 12 in the operating range. Reports from users indicate that its use produces no offensive fumes. Oakite Products, Inc.

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Paper Tells How Sodium Detects Steam Quality

Consultants on industrial water problems have announced the availability of technical paper 135 entitled, "Conductivity Versus Sodium By Flame Spectrophotometer In Steam-Purity Studies."

This technical paper presents results of extensive laboratory and plant work to indicate that sodium is extremely valuable in evaluating steam purity. It is far superior to conductivity and is sensitive enough to detect the solids and the wetness of steam of very high quality. Betz Laboratories, Inc.

Circle E26, green card, last page

Pressure Comparator Shows Differential Pressure

A new pressure comparator has been placed on the market. Hitherto, this device had been used as a component of the company's data reduction systems.

The precision pressure comparator relates an unknown pneumatic signal to a reference pressure. When the two pressures reach an equilibrium, an electrical contact is opened. Leads from the comparator may be used to indicate a zero differential pressure. The comparator is suitable for use as well with any non-corrosive fluid. A feature of the comparator is its extensive duration of service, at least 500,000 cycles (about 50 times that of similar devices). Fischer and Porter Co.

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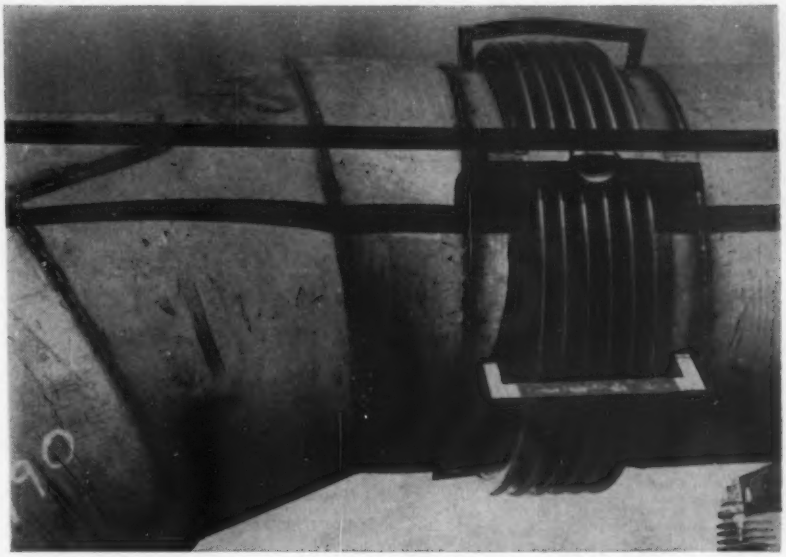

Expansion Joint Allows Increased Flexibility

A "new look" in expansion joints is about to go on stream at Texas Butadiene and Chemical Corp.'s Lyondell plant near Houston.

The different curvilinear corrugation design which results in a more uniform movement per corrugation is based on a careful correlation between the shape, height and pitch of the corrugations. The natural, all-curve shape results in lower flexing stresses and increased flexibility. The engineering features incorporated in the curvilinear corrugations offer this better equalization of movement even without reinforcing rings. Because of these features, longer cyclic life is assured. Weight is 50 percent less than conventional joints. Badger Manufacturing Co.

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PETROLEUM REFINER, August, 1957

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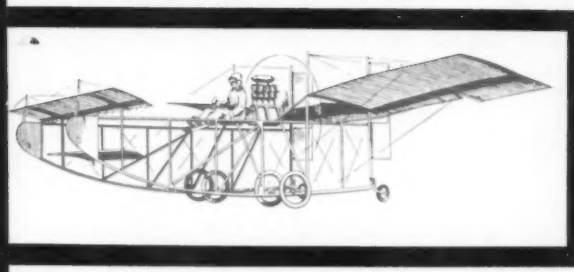
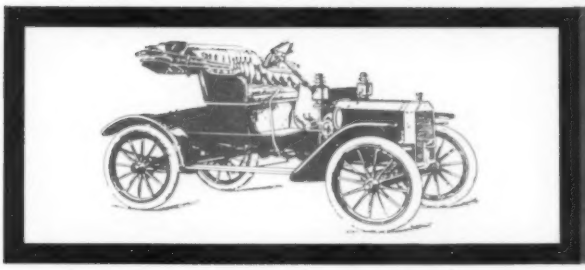
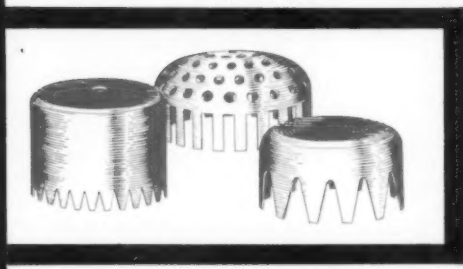
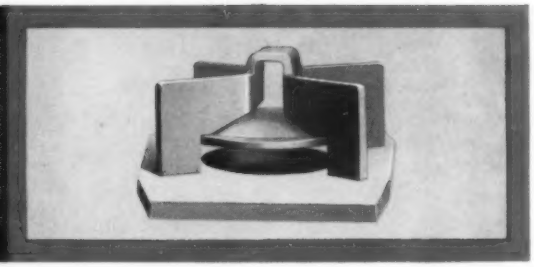


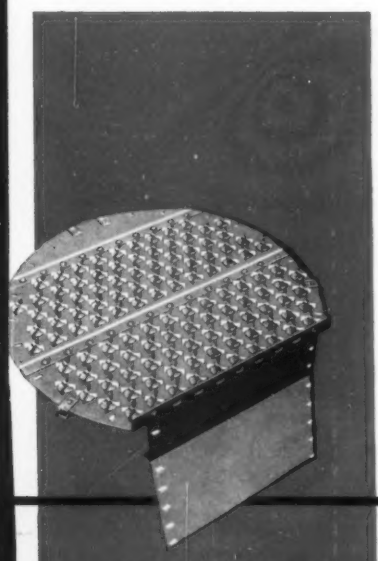
some changes made



in fractionating trays, too!







Today's trend in progress is away from "horse-and-buggy" bubble trays to Koch's jet-age **FLEXITRAY** . . . and, for good reason!

With "Flexitray," the entire tray area is available for vapor-liquid breakout . . . no obstruction to liquid flow exists . . . vapor separates at lower velocities. "Flexitrays" remain cleaner – longer!

With its extreme flexibility and capacities, it is small wonder that major companies – looking for the best designed trays – have adopted "Flexitray" for more than 400 **NON-CAPTIVE** installations.

Write . . . wire . . . phone your nearest Koch representative or:

KOCH ENGINEERING COMPANY, INC.

DESIGNERS AND FABRICATORS OF MODERN TRAYS
321 WEST DOUGLAS AVENUE, WICHITA 2, KANSAS

REPRESENTATIVES

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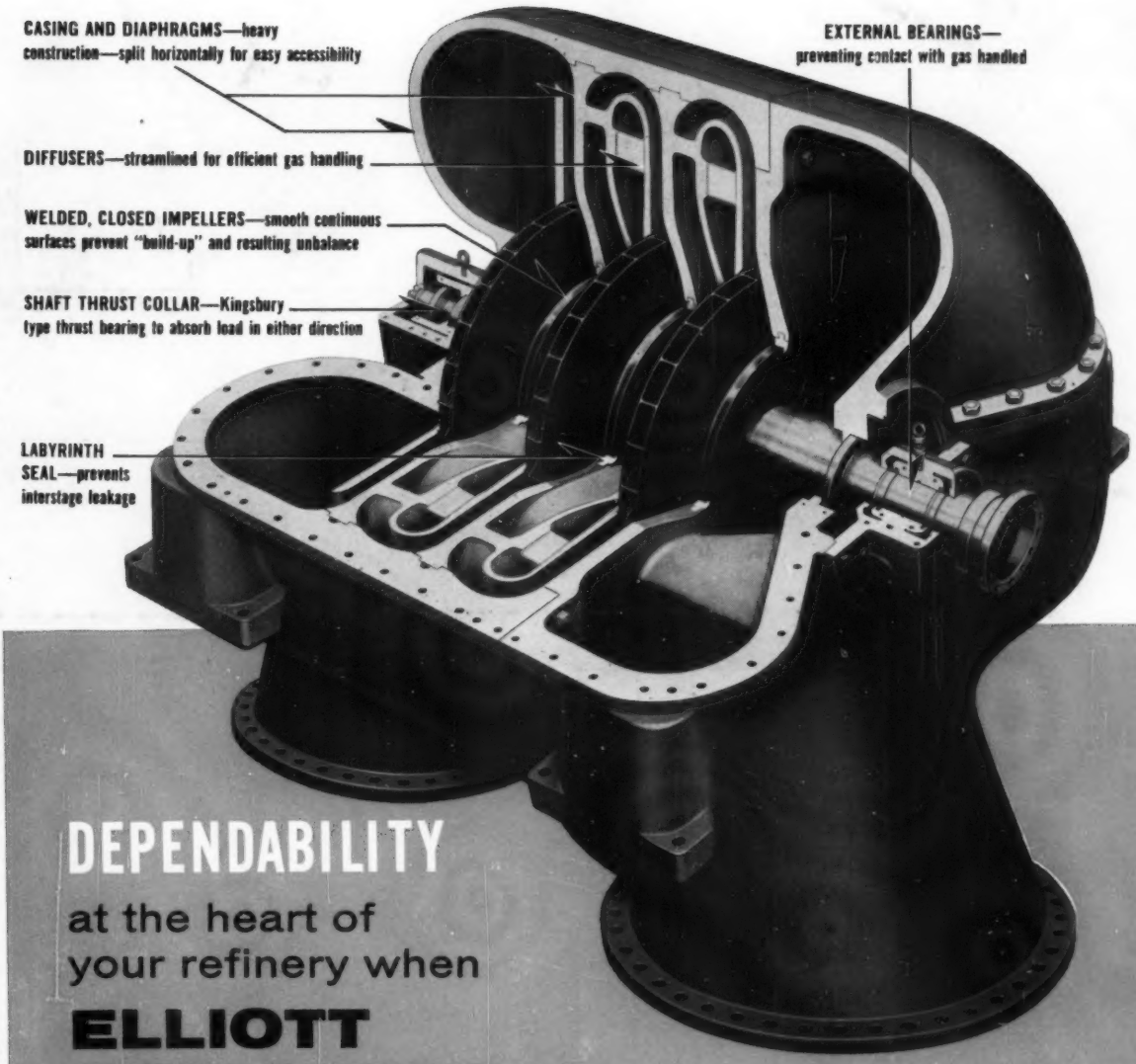
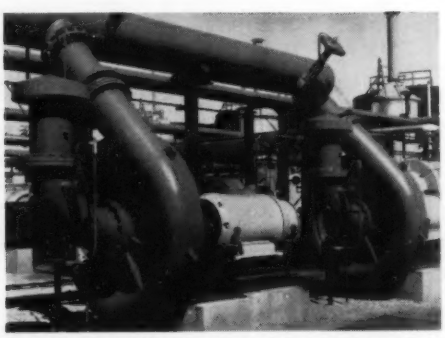
Tulsa, Oklahoma Representative: W. C. Myers Company, Wright Building
Houston, Texas Representative: Alpha Engineering Company, P. O. Box 12371
Pittsburgh, Pennsylvania Representative: D. D. Foster Company, 501 Alcoa Building
West Coast Representative: Jacobs Engineering Company, Pasadena: RYan 1-9373; Oakland, TEmplebar 2-5391
Illinois Representative: M. B. Fisher, 1521 Courtland Avenue, Park Ridge, Illinois


CASING AND DIAPHRAGMS—heavy construction—split horizontally for easy accessibility
EXTERNAL BEARINGS—preventing contact with gas handled
DIFFUSERS—streamlined for efficient gas handling
WELDED, CLOSED IMPELLERS—smooth continuous surfaces prevent "build-up" and resulting unbalance
SHAFT THRUST COLLAR—Kingsbury type thrust bearing to absorb load in either direction
LABYRINTH SEAL—prevents interstage leakage

DEPENDABILITY

at the heart of
your refinery when

ELLIOTT CENTRIFUGAL COMPRESSORS are in service!



Two of three Elliott motor-driven single-stage centrifugal compressors serving oil black plants in Oklahoma. Each compressor is rated 5255 inlet cfm, handling air at atmospheric pressure and boosting it to 3.85 psig.

Elliott centrifugal compressors are designed and built with the simplicity and ruggedness that pays off in *dependable,* long-term, non-stop performance. Available in single and multistage types . . . for inlet capacities up to 150,000 cfm and pressures up to about 500 psig equivalent air pressure . . . turbine or motor driven . . . with or without step-up gear. For further details, call your nearby Elliott District Office or write Elliott Company, Compressor Department, Jeannette, Pa.

ELLIOTT Company

P7-3